VOL. XXVIII. — No. 3. MARCH 1951.

Monthly Bulletin of the International Railway Congress Association

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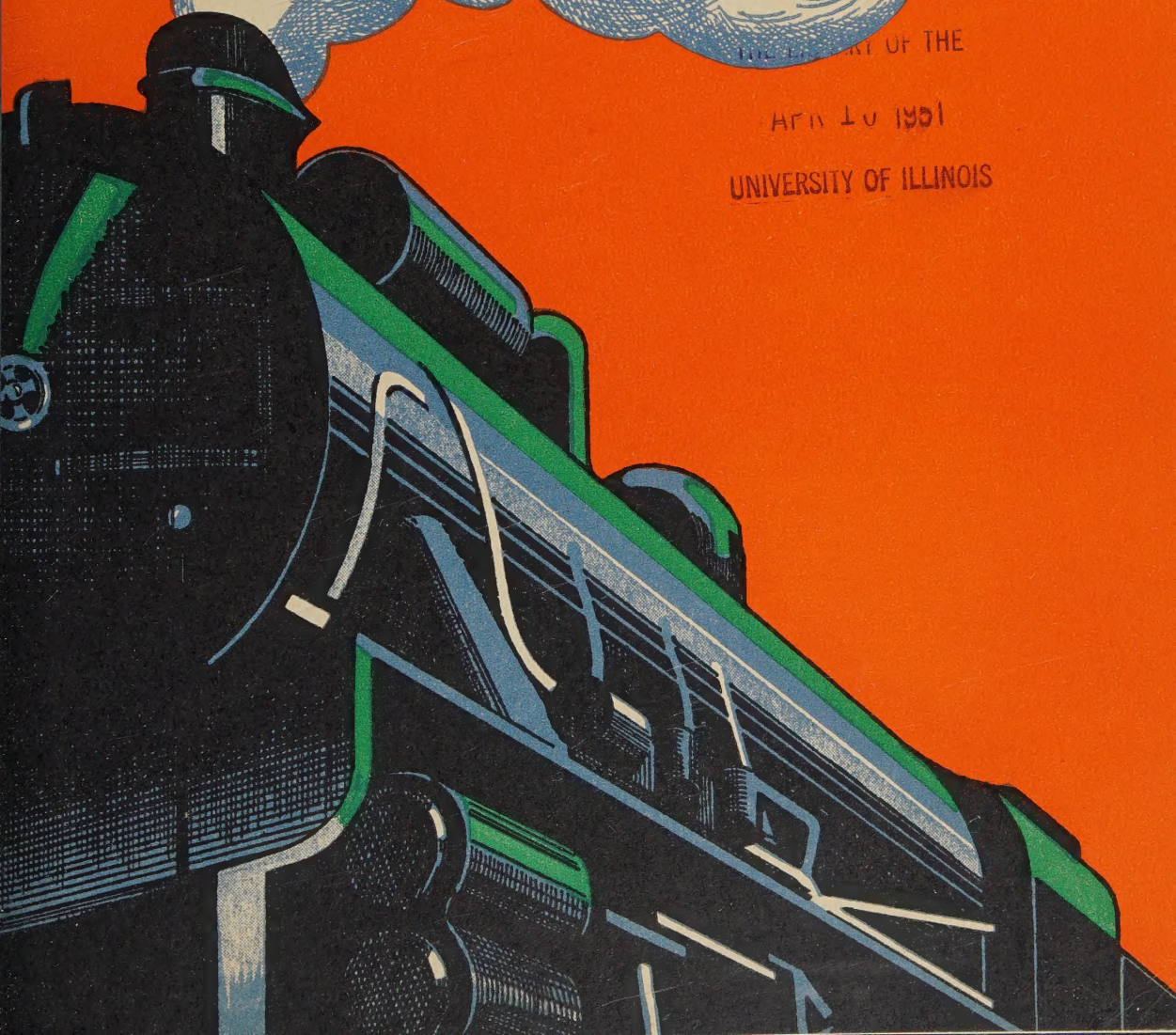

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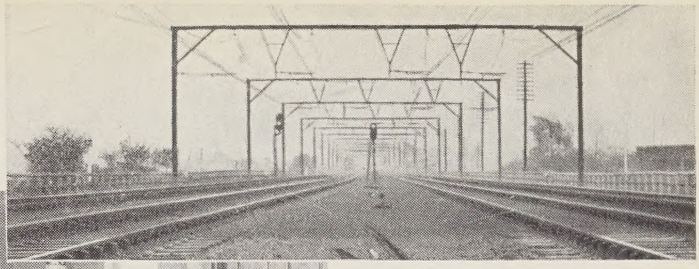

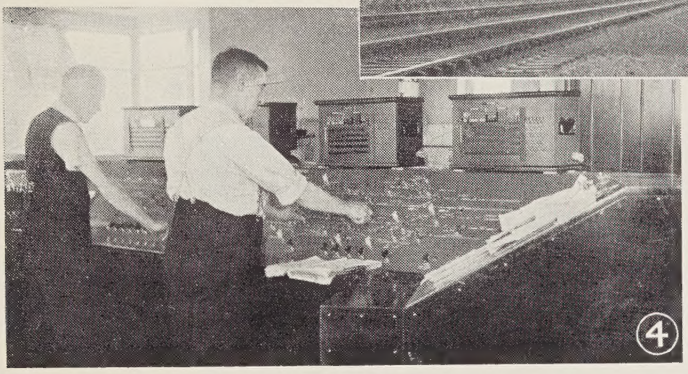

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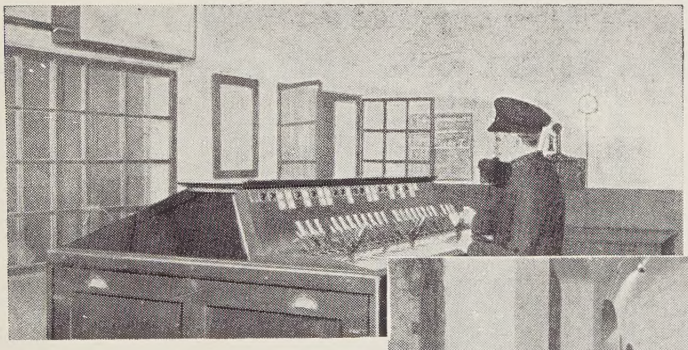

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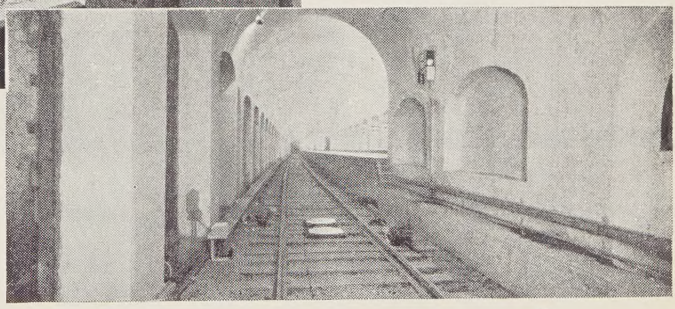

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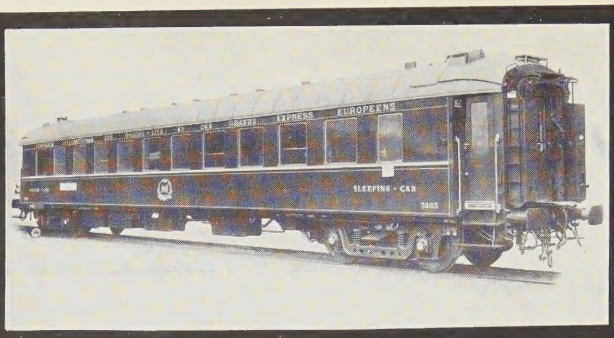

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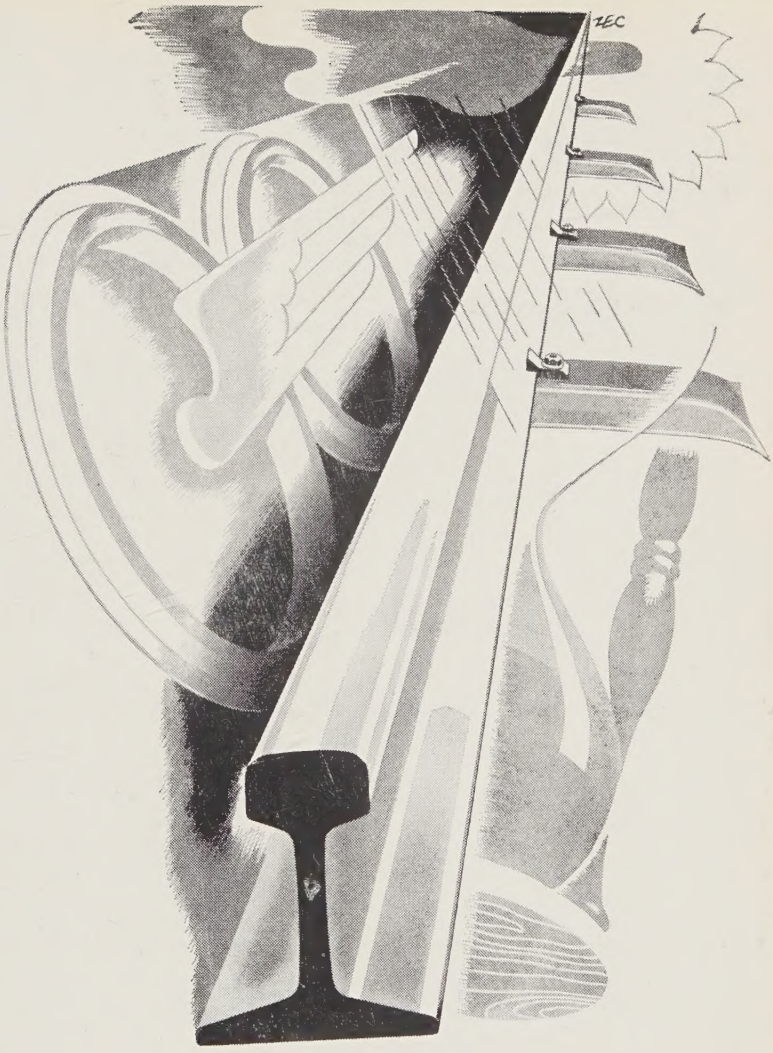

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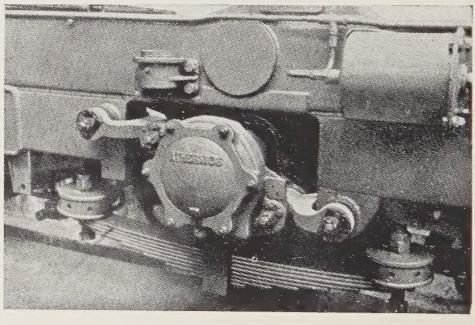

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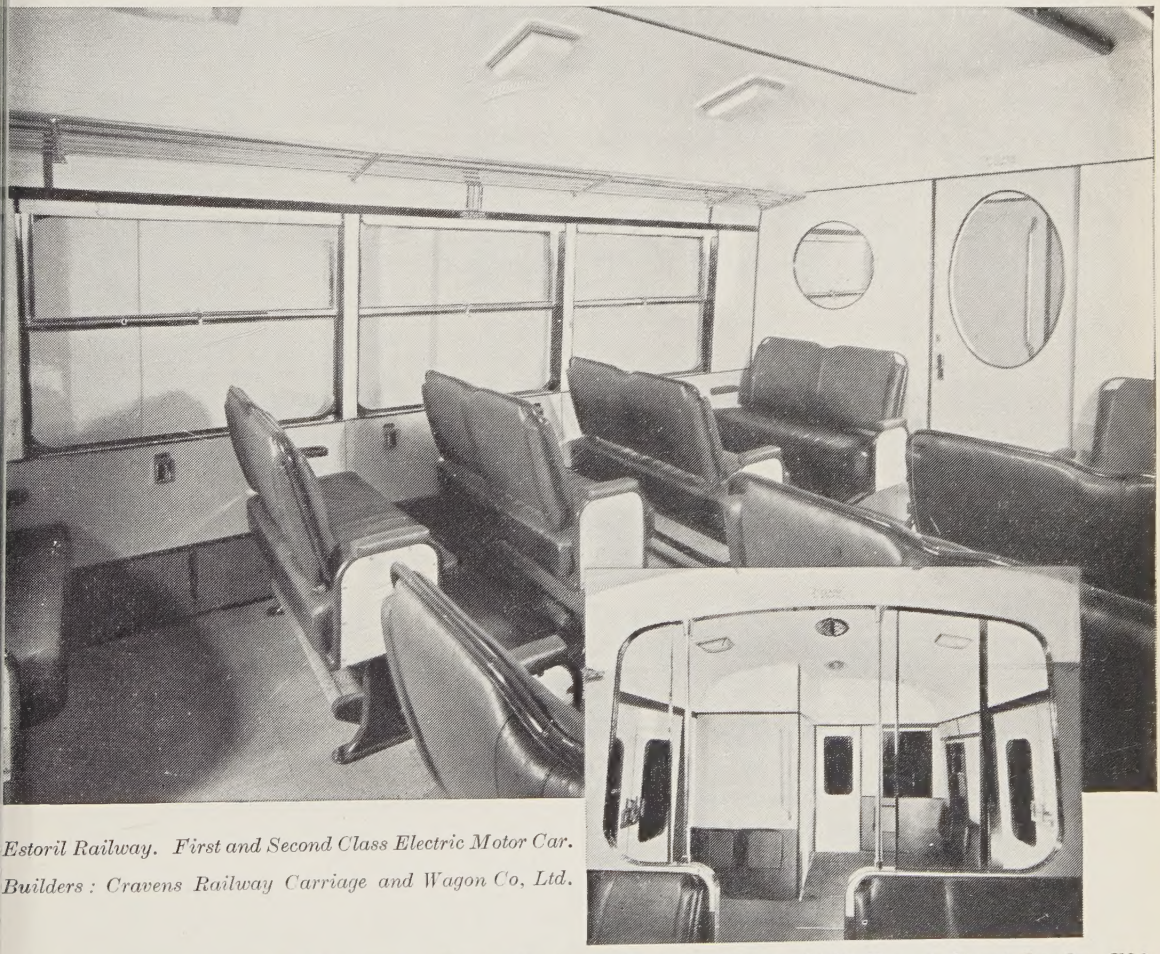

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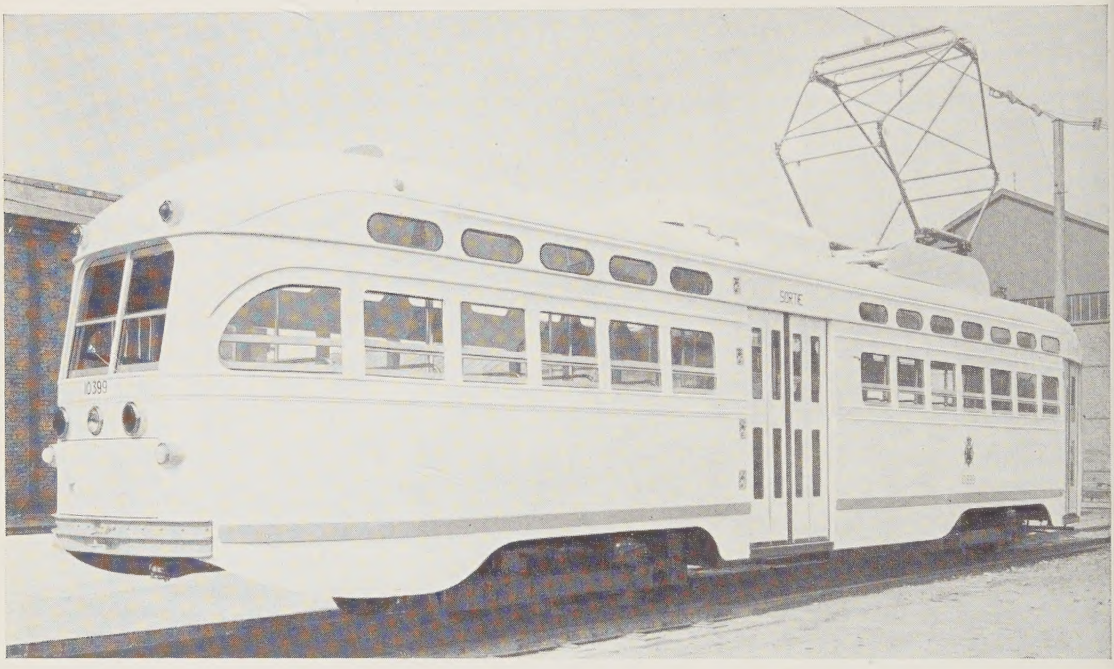

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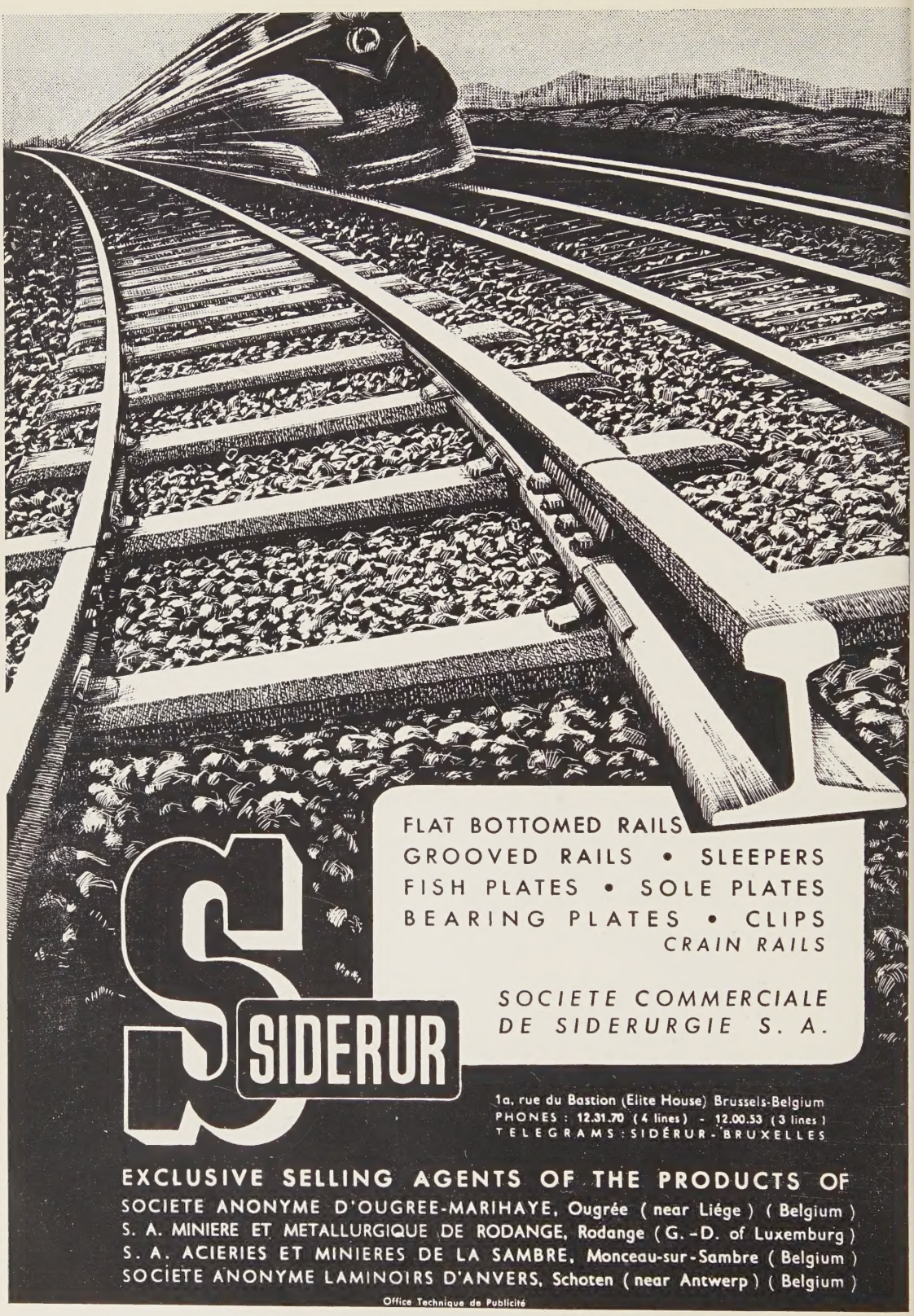
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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
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(ENGLISH EDITION)

[385. (09]

The future of railways,(*)

by ir. F. Q. den Hollander,
Prresident of the Netherlands Railways.

(*From the Journal of the Institute of Transport, January 1951.*)

1. Transportation in modern human society.

Transportation is one of the most important elements of our human society. Without the possibility of transporting people and goods extensively, it is impossible for present-day man to live adapted, as he is, to far reaching divisions of labour and specialisation of production. Transportation, and consequently traffic as a whole, is therefore a matter of public interest. As the division and specialisation of labour progress, so the number of social relations increases, social life becomes more intensive and people live more compactly, and so in the same degree human society becomes more vulnerable. This vulnerability will be smaller as transportation—and consequently the means of transport— is completer and better. Speed, frequency, and safety are absolute requirements for all forms of transport. Traffic interruptions occasion disturbances in a complicated social apparatus.

The great public interest of transport finds its expression in government interference which for more than a century has been increasingly growing. Where private enterprise was deficient or was insufficient, government took the lead. In an increasingly complicated economic order, it is essential for public transportation to be more and more regulated by government and, if necessary, to be state owned but operated as a public enterprise, on the lines of a commercial undertaking. It is the same with the transport and distribution of energy, just as with that of letters, telegrams, and telephone calls ; they are also of public interest and no modern society can any longer afford to have them under separate managements. The ties between government and railway transport are everywhere very close. So also with road, water and air transport ; private enterprise cannot be allowed simply to have a free hand.

2. Analysis of traffic requirements.

In a transport system which requires heavy capital investment, unbridled competition quickly results in an intolerable excess of equipment and personnel, both of which are necessary for other departments of human society which would consequently suffer deficiencies of them.

Under prevailing conditions, an exact analysis of traffic requirements and an estimate from it of future traffic demand for each of the components of transport is continuously necessary.

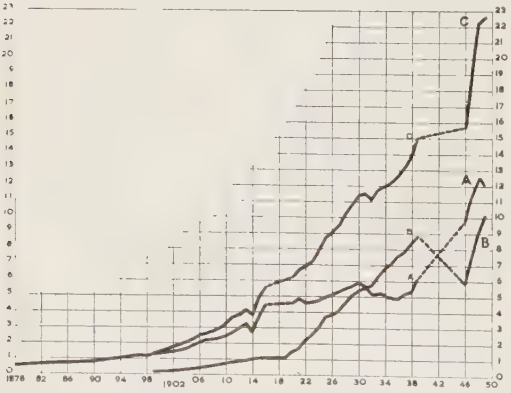
On considering the development of passenger transport in the Netherlands for as

(*) Paper read in London on November 20th, 1950, before the Institute of Transport.

TABLE I. — **Number of motor-cars, motor cycles and bicycles (000's).**

Passenger motor-cars	Netherlands	Belgium	France	United Kingdom
1919	60	92	930	970
1934	90	121	1410	1298
1939	100	155	1745 (1938)	2034
1949	113	161 (1948)	985 (1948)	1940 (1948)
Motor cycles				
1929	30	46	—	705
1934	44	65	—	524
1939	66	65	—	418
1949	82	92 (1947)	—	559 (1948)
Cycles				
1929	2579	—	6767	—
1934	3133	2131	6969	—
1939	3730	2895	8320	—
1949	—	2619 (1947)	—	—

long a period as possible, a picture is obtained of a gradually accelerated increase in the volume of transport. This accelerated growth is due to the increase of transport by private methods of transport, such as the motor-car, bicycle and motor bicycle. Private means of transport are replacing public means and the increase of private transport exceeds the retardation in the growth of public transport.



A — Total of public means of transport.
B — Total of private means of transport.
C — Total (A + B).

Figure 1. — Development of total traffic in the Netherlands.

Again and again, it is supposed that saturation has been reached in the use of private means of transport and every time this supposition turns out to be wrong. The bicycle and motor-car industries—strong as they are—are looking for new fields and will certainly find them. The bicycle has improved, the light motor bicycle or bicycle with auxiliary motor, is increasingly finding favour. The motor-car, owing to the development of small types, is within the reach of an ever growing number of people. Table I showing numbers of private road transport vehicles illustrates the development.

In the long run, this development comes up against the overloading of the roads where there is heavy traffic, and of the streets and parking places in the business parts of the big towns. It is especially because of the taxes paid by them that private road users claim a better provision of parking places, more space to move in, and better, speedier and safer roads. This claim is being met; important schemes are being planned and gradually carried out. So the shifting from public to private means of transport is, in this respect, still left free. All important places are connected by broad

National highways.
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Railways operated for goods traffic.

Figure 2. — National highways and railway systems of the Netherlands.

national highways, and this system is still being improved and supplemented. From the map (Figure 2) it appears that the system of large national highways in the Netherlands is practically a duplicate of the railway system.

This explains the shifting from rail to road. The latter tendency is not restricted to a diversion from public rail transport to private road transport, but also takes place within public passenger transport, viz. from train to motor bus.

On the basis of the figures of the development of traffic in the past, the population returns, the production indices and the data of the spread of industry, it is possible to make a rough forecast of the traffic volume for every country.

3. Division of task.

a. Passengers

At the outset, railways had the start of the other means of transport to such an extent that restraint was put upon them by government in order to protect the user—water and road transport were practically not interfered with. When road transport began its phenomenal development there was in this respect a gap which was filled only very slowly and then only after a period of years, greatly in haste. During the first period of development, this resulted in unbridled competition on the part of road transport which was highly detrimental to the railways. Gradually, regulating legislation for public passenger transport was developed. Besides introducing a licensing system this legislation aimed at amalgamating undertakings and the Netherlands may be mentioned as a good example of this.

The country motor bus undertakings existing in 1937, numbering 496, were in some ten years concentrated into 95 undertakings, 19 of the largest of which came into the hands of the railways by mutual agreement. Of the remaining number, four are in the hands of the government, and six are semi-government undertakings. This made it possible for public passenger transport to be controlled on the most important points and yet to retain its dynamic character. This is very important, because transfers of traffic are now no longer influenced arbitrarily by an uneconomic unrestricted competition, but can take place deliberately after being duly regulated beforehand.

Railways are threatened with diversion of traffic not only to road transport but also to air transport. Railway traffic, especially that of first and second class long-distance passengers, can be affected by air transport very seriously. However, the relation between air and rail transport can be regulated in a similar way to that indicated previously for road transport. The independent character of both means of transport need not be affected by this procedure. Participation in one another's undertaking and periodical consultations of the managements will suffice to unite policy and to prevent undesirable competition.

b. Goods

Less clear and satisfactory is the situation with regard to goods transport. The regulation of this transport is still in its initial stage in the different countries.

In goods traffic private transport plays a very important part. Data on this subject are very inexact and, in the absence of government regulations, only to a limited extent available; suffice it to say that it would seem that public means of transport is experiencing a diversion of traffic to privately-owned transport.

The share of the railways in the total of goods transport varies from country to country and is in a high degree dependent on the geographic and economic structure of the country concerned. In the Netherlands goods transport by water comes conspicuously to the fore. The share of water transport in the total transport of the Netherlands is more than two and a half times as great as that in Belgium, whereas in the latter country the share of the railways is twice as great as in the Netherlands. This is mainly due to the Netherlands being

Table II. — **Goods traffic in the Netherlands.**

	By rail		By road		By water	
	Tons 000s	T/km 000 000s	Tons 000s	T/km 000 000s	Tons 000s	T/km 000 000s
1938	9 544 (17.3%)	1 360 (26.7%)	20 000 (36.4%)	1 190 (23.3%)	25 500 (46.3%)	2 560 (50.0%)
1949	15 180 (17.1%)	2 201 (33.1%)	41 200 (46.3%)	912 (13.7%)	32 479 (36.6%)	3 534 (53.2%)

situated in the delta territory of some large rivers, with consequent differences in character between the great harbours of Rotterdam and Antwerp.

The share of the railways in the inland public goods traffic of the Netherlands is shown in Table II.

A striking fact is that the Netherlands Railways have succeeded in maintaining their share in the weight transported (which is relatively small) but that water transport has had to surrender a great part of its traffic to road transport. However, the figures concerning the ton-kilometres run, show that road traffic is strongly and increasingly concentrating on the short distances.

If the whole of the development up to the present time is viewed, it becomes evident that each of the four means of transport—railway, road, water and air—has gradually captured for itself—the one far more rapidly than the other—a certain volume of transport.

In the future, the total of the traffic will undoubtedly show a considerable further increase. The number of passengers is closely connected with the increase of the population and the further development of industry ; industrial specialisation and decentralisation imply more passenger traffic. In the period 1878 to 1938 which witnessed great industrial development and during which period the Netherlands population doubled, passenger traffic increased thirty-four fold.

Such an enormous increase is not to be expected in the future ; nevertheless, it is more than ever before necessary, after analysing the transport present and future requirements, to try and make a division of the total task. This total task comprises the transport of all people and all the goods offering. This must be looked upon as one whole which according to the technical, economic, social and geographical circumstances is to be divided among the four means of transport.

Strictly speaking this division of traffic must not result in duplication, not even in overlapping—this leads to waste of people and money. The division is not permanent —shiftings will continue to occur. Technical progress and the economic fluctuations accompanying it will constantly, over a shorter or longer period, show changes.

It is from this viewpoint that the task of the railways must be determined.

4. Task of the railways.

As the conviction is growing in the mind of the general public that regulation and co-ordination of transport under government control cannot be dispensed with, we may start, by trying to construct a future picture of the railways, from the supposition that any unwarranted expansion of any branch of transport will not be allowed. For each transport branch, the place must be determined on the basis of its expected technical and economic development in conformity with the traffic forecast.

For railway undertakings this determination of sphere is most important. They need stability inasmuch as they have to organise themselves for long periods, with the result that they are far more vulnerable than road and air transport, which like water transport, are not burdened with the cost of their way, safety appliances and—as far as road and air are concerned—stations.

Before considering the task of the railways concretely, it is necessary to distinguish their position clearly.

Every society—looked upon as one nation—requires a national transport apparatus for social, economic, cultural and state reasons, linking together the whole territory of the nation in its main arteries, having operating and transport obligations, and fulfilling these obligations within limits acceptable to the population.

The railways with their considerable transport capacity, their great speed and consequent possible short carrying-time, their high regularity and safety, will be able under all circumstances, to satisfy these demands in a manner of which no other means of transport is capable.

In this national position, however, their task will all the same be restricted, since outside the main lines all other traffic arteries have to be subjected to other standards—in the first place economic standards.

5. Financial structure of the railway.

In order to be able to perform its function in the public interest and to continue to do so, it is essential for the national transport apparatus to lead a healthy life. This implies that it will be possible for the railways to be the national means of transport, only if they can perform their task efficiently and economically.

It is intolerable that undertakings, including public ones, should perform services with constant losses. This theory is proved by the *reductio ad absurdum*. If all should work at a loss, how could this continue? Once losses start, there follows the recovering wholly or partly of such losses, from resources which should be employed for depreciation, with the result that no renewals or only partial ones are made and, consequently, the undertaking becomes more and more out of date.

The undertaking that is to be a « national » one indeed, must be able to keep rejuvenating permanently by renewals and modernisations. This is possible only if from year to year the amount for depreciation is fixed at the exact level and provided this amount will really become available for renewals.

Besides this, it must be accepted as axiomatic that the capital by which the undertaking works, shall receive the normal return, in other words that interest and dividends must be earned.

If therefore we start with the revenues from traffic, and determine the amounts necessary for the maintenance of the undertaking on a modern basis, for taxes, and for return on capital, we get the amount which can be used for operating purposes.

6. Revenue.

The revenue, and hence indirectly the traffic volume, requires constant attention, expressing itself in tariffs capable of being adapted—in a commercial sense—continually.

In endeavouring to retain the share in the traffic, some important stabilising factors are of influence. In the Netherlands there are several of these factors, which are of significance.

The railway system is relatively small compared with the road system, but it serves the principal districts of the country connecting them one with the other. The railway undertaking has surrounded itself, in a subsidiary relation, with some 19 motor bus undertakings providing passenger transport on many regional feeder lines in connexion with the railways. For goods transport, it has at its disposal a national road transport undertaking, which handles collection and delivery regionally and locally and which, further, provides for the

regular senders by railway, by means of trunk services, that transport for which the railway itself is not suited.

In equipping itself, the railway undertaking is guided by the volume of traffic, both passenger and goods, to be expected on the basis of the transport analysis. It strives after a maximum of efficiency and facilities with the result that it offers services which are not inferior to or more expensive than those offered by the other transport branches.

In this connexion, the following should be observed with regard to the network.

As in the case with the networks of all railway undertakings, the Netherlands Railways network is of historical growth. This growth was not harmonious; the lines differed in importance. To the important main lines were added lines of more or less important regional significance. This is clearly illustrated by the division of the passenger revenues. If the lines of the system are considered according to the measure of their revenues, it appears that 43 per cent of the revenue is yielded by only 10 per cent of the length of the network. On 70 per cent of the system, 95 per cent of the revenues is obtained; the remaining 30 per cent yield only 5 per cent.

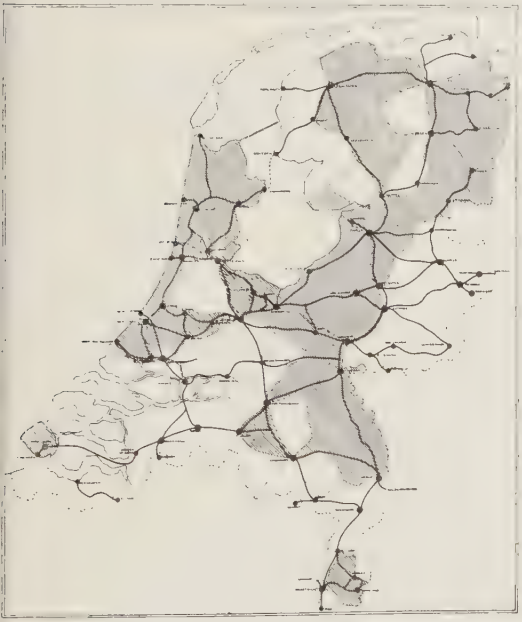


Figure 3. — Map of the Netherlands Railways including the district (shaded) of the 19 regional undertakings.

If the revenue should no longer cover expenses and the undertaking consequently should become deficient, and if all the technical and commercial means which might maintain the financial balance are exhausted, it is necessary for the lines of those 30 per cent to be further examined. They are there for historical or traffic-political reasons or perhaps for reasons of an economic-political character, constructed at a time when other means of communication were less common. They must, however, never become the cause of the decay of the whole system; the traffic will, under such circumstances, have to be transferred to a means of transport which is able to carry it in a way which covers expenses.

7. Operating expenses.

An exact and constant analysis of expenses, split up as far as possible according to passengers and goods, and also to the clearly distinguishable lines and groups of lines, is absolutely necessary. This will prove that on a number of lines of the system the railways have in fact lost the struggle. They have fallen into the dangerous downward spiral; revenue has decreased because of diversions to other means of transport, the results of the system as a whole have no longer admitted of renewals which might have prevented the wearing away, expenses have increased on account of the obsolete stock and obsolete permanent way, service and comfort have decreased, with the result that an ever increasing number of passengers on these lines have turned to the modern motor-bus. This caused the results on these lines to decline further, resulting in the picture we know only too well at present—the railway sometimes very much out of date, and

by the side of it the modern super highway with motor-bus, motor lorry and private transport rushing along at high speeds.

The railway authorities will have to recognise and accept this position. They will have to watch their network permanently, either the lines separately or in groups. The traffic value has to be calculated not only for the present time but also for the future. Opposed to this must be placed the investments and the operating expenses for the different modes of transport known to science at the present day—steam, electric and diesel-electric traction on the one hand, and motor-bus and motor-lorry on the other. If there are lines which prove to be worked at heavy losses—which lines or groups of lines, being unremunerative have, as a matter of fact, become superfluous—only two measures are left which can be applied to them :

a. Operation is continued without renewals, and as soon as the direct costs are no longer covered, operation is discontinued for passenger and goods traffic, or for passenger traffic only.

b. Operation is discontinued immediately either with or without maintaining the line for goods traffic.

In case the discontinuance of the service in any form whatever is deemed unacceptable by government in the public interest, the operation of the line will have to be continued at the expense of the government, which will have to pay the deficit as soon as the operating accounts of the whole system show a loss.

If, in this sense, railway systems are examined critically, many kilometres will in fact come up for closure, in whole or part.

The question arises immediately whether the facilities are to be replaced and if so by whom. In many cases the replacing means of transport will already be available since it is this very same means of transport which has occasioned the decline of the railway. In order to guarantee to the district concerned that, after the suspension of the railway, the necessary services are afforded, two measures have to be taken :

a. Operation and transportation are made obligatory for the replacing service.

b. In the concession of the motor-bus undertaking must be included such routes as will secure the effective linking up of the network of the motor-bus undertaking with the railway stations concerned.

As a replacement service the regional undertaking is the most suitable, since this can be adjusted wholly to the needs of the district. The district can be represented in the undertaking and make its influence felt in it. The regional undertaking can provide for the district a complete and fully organised transportation service.

Moreover the regional motor-bus undertaking must operate its services in such a way that the district feels itself as a part of the national transport system. In addition to good connexions with rail transport a complete system of through tariffs is also desirable to that end.

It must be admitted that thus far so drastic a curtailment of the railway system as just mentioned, has only partially been achieved, and on many systems may not be attempted to such length.

The Netherlands Railways, however, have been intensively occupied with this matter since 1938.

It is also due to this process that the Netherlands Railways now have a very great density of passenger traffic (Table III).

Nevertheless, the Netherlands Railways system has as yet not attained stability as a paying concern ; more passenger traffic will have to be transferred to the road in the near future. On the other hand the construction of very promising new railways is conceivable. These may include a direct line from the Hague to Amsterdam, 60 kilometres long, which will doubtless cause passenger traffic to pass from road to rail and which will greatly contribute to the development of the traffic.

If, therefore, on the one hand this is con-

TABLE III.

Density of passenger traffic, 1949.

	Passenger-kilometres 000 000s	Sections	Passenger-kilometres per section kilometre 000s
Netherlands	6 478	3 208	2 019
France	29 441	41 305	713
Belgium ...	7 116	5 026	1 416
Switzerland (S.B.B.) ...	5 864	2 975	1 971
Italy	20 576	16 250	1 266

tinued, it will be necessary on the other to watch permanently the different elements of operating expenses and to try and restrict these expenses by renewing and modernising.

The financial course of business with the Netherlands Railways for the year 1949 may serve as an example :

	Guilders 000 000s	
1. *Operating expenses* :		
personnel	116	
motive power	36	
other	62	
	——	214
2. *Depreciation* :		
tracks, yards and bridges. . . .	28	
rolling stock and electrification. .	33	
buildings and investments . . .	4	
	——	65
3. *Interest and profit*		7
		286
4. *Revenue*		286

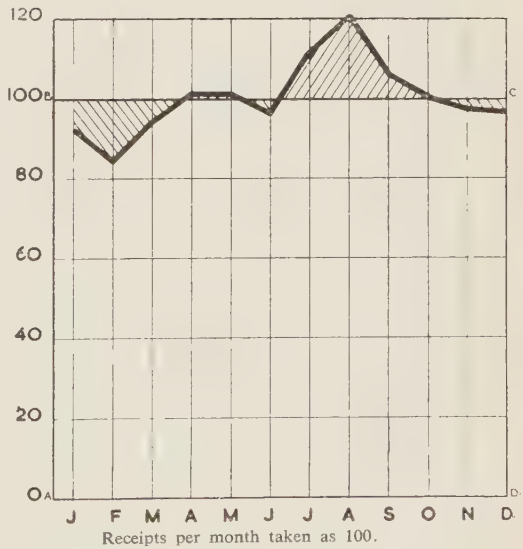
These figures show the special significance of some items : personnel with 40 per cent ; motive power with 12 ½ per cent, and depreciation with 22 ½ per cent of the total expenses.

It is useful to consider these items further : in doing so it is first necessary to determine further the form in which operation has to take place.

First and foremost is must be held that even though a system has been reduced to the lines which as a whole make paying operation possible, the rule of conduct should invariably be that the service must be better than that afforded by road, air and water transport, special attention being paid to the feeder services on the road.

An important question arising with regard to operation is the question of the size of the undertaking. The total of the traffic which according to the traffic forecast may be expected during a year is not distributed over the 12 months evenly. The season-pattern of the Netherlands Railways for instance is shown in Figure 4.

If it is considered to be the task of the undertaking to carry also peak traffic with normal comfort and service, this will mean that the undertaking has to equip itself (both with regard to personnel and stock) for a transport volume equal to the rectangle with the year as the base and the high-



Receipts per month taken as 100.

Figure 4. — Netherlands Railways : Index figures of traffic receipts per month.

est peak as the vertical. This causes the rolling stock to be utilised much less than capacity outside the peak periods, and this in its turn is the cause of considerable losses. Not infrequently endeavour is made to cover these losses due to an excess of stock, and an excess of yards and tracks, by attracting extra traffic at special rates. Generally speaking these special rates upset the fare-basis with the consequent result that a relatively great percentage travels at reduced rates.

The reverse ought to apply : practically all passengers must travel at normal rates, which in that case can be relatively low. Railways subsist on such passengers as make use of the railway services daily and not on such as apply to them a few times a year to be transported. It is not intended to deal here with the problem of the most favourable size of the undertaking but it will be clear that the undertaking had better adjust itself to a traffic volume as indicated in figure 4 by the rectangle A, B, C and D. The peaks have to be met by the restriction of maintenance during these periods, by filling up all available carrying space with the goodwill of passengers and senders. Where this goodwill does not exist it is far cheaper to let them turn to the other means of transport than to try and retain them by additional investment.

a. Personnel expenses

If the size of the undertaking in its stock, permanent way and works were on this basis restricted to the greatest possible extent, it is necessary to analyse the principal expenses factors and bring them within the financial limits of the undertaking. Of these expenses, those pertaining to personnel form a very important part.

As industrial peace in an undertaking of such fundamental importance for the national economy as the railway undertaking, is of prime necessity, the working conditions safeguarding this peace, must be good. Within the economically justified limits of the operating expenses this is only possible if the personnel is as small as possible.

Here a vital point is touched upon.

In general it will not be possible for the directly-productive personnel to be noticeably reduced. Nevertheless it is absolutely necessary to keep a permanent watch on everybody's task and to take full advantage of every modernisation to reduce the personnel.

As a matter of fact, indirectly-productive personnel is almost everywhere still too large in number. As to this point it can be said that administratively a simplification is possible. Without adapting or doing away with old working methods, new ones are introduced, and this has resulted in an ever increasing number of those employed in the administration (Table IV).

TABLE IV.

Netherlands Railways — Personnel.

	Total	Headquarters
January, 1940	32 722 (100)	1 991 (100)
January, 1946	41 220 (126)	3 725 (187)

For such increases of administrative personnel, no undertaking can afford the money ; they must be swept away without delay. No more can the indirectly-productive personnel be allowed to do work that is not purely railway work. This kind of work is not of a permanent character. Much of it can be better designed and planned by specialised offices and executed by contractors and factories. The great advantage of this is that the railways in this way share in the experience gathered in other enterprises.

Besides it is psychologically wrong to insist on doing everything oneself ; for trade and industry it is very interesting to be allowed to do work for the railways, and at the same time it acts as a stimulus to them to use, for their personnel and goods, the railway which is such an important client.

It is this element of reciprocity, however, which plays an important part. This reciprocity contains another important element. Industry may do for the railways the same as it does for road transport and aviation. Instead of keeping initiative and the lead altogether to themselves, the railways must allow industry to have a share in them. Industry can supply complete constructions, build and test prototypes all of which can be mass-produced afterwards.

Especially in the U.S.A. is this development perceptible, doubtless under the influence of the automobile industry.

The great strength of the automobile and aviation industries is that they offer a standard product ready for use under their own mark and complete responsibility.

Moreover, air and road transport have acquired in this way an enormous advantage in the matter of spare parts. Railways are at present obliged to store a large supply of spare parts, because with the series ordered the production generally ends. In these spare parts much capital is not only invested, but also lost.

The objection which might be raised to this industrial development and may be « management » will doubtless prove to be fictitious. With road and air transport no difficulties are felt ; on the contrary, their development has been due only to industrial activity. Industry will never abuse the dependence of their customers.

This applies not only to the construction of new objects but also to the execution of big repairs. A great advantage of this is that industry in doing extensive repairs also notices the defects and deficiencies of its own products and can correct them in new constructions.

From this point of view, all activities without any exception of the construction and purchasing offices as well as the workshops of the railways must be greatly reduced. For the various railways such a procedure would result in considerable reductions of fixed costs. Obviously their policy on this point varies greatly. This is proved by the personnel strength per 1 000 produced train-kilometres which differs a good deal for the different countries (Table V).

TABLE V.

1948	Total	Personnel per 1 000 tr.-km
Belgium	92 063	1.31
Denmark	28 166	1.00
France	477 467	1.31
Great Britain ..	648 740	1.10
Italy	186 401	1.49
Netherlands....	39 355	0.88
Switzerland	37 910	0.64

According to the standards developed for the Netherlands Railways a total personnel strength of 32 500 would be sufficient a the present time—30 000 permanently and 2 500 temporarily employed. This means, rounded off, 0.66 men per 1 000 train-kilometres, and gives a reduction of personnel expenses of 22 500 000 guilders. Consequently this amount forms 8 per cent of the total of the company's expenses and creates a reserve against fluctuations of trade.

b. Motive-power expenses

In many countries the consumption of energy is greater—at least it could be greater—than the production. Consequently not only the amount of this item—12 ½ per cent of the total—but also national economy makes it necessary to restrict the consumption of energy for transport purposes.

Seen in this light except under restricted circumstances for train as well as for shunting service, steam traction is no longer ac-

ceptable, now that other and thermically far more favourable modes of traction have developed. On the one hand there is the full-electric traction, which centralises the energy-service and the diesel- or gasturbo-electric traction. Both forms have been considered in more details before, recently in the paper by Sir Eustace Missenden on « Some thoughts on railway motive power » (*).

c. Other expenses

Although these expenses, representing 62 000 000 of the 286 000 000 or 21.5 per cent, do not as a group seem important, the contrary is true since this item includes the expenses for maintenance.

Maintenance may become an unbearable burden with the railways if the assets begin to show signs of becoming too old, a tendency which proceeds from lack of renewals at the due time. A regular renewing on the other hand may reduce the maintenance to a large extent and lower the total of this item accordingly. These expenses must therefore be seen as an important part in connexion with the capital investment.

It would seem that in the railways they have some difficulty to grasp this connexion; sometimes they are inclined to maintain *ad infinitum*.

8. Depreciation.

In the first place it is necessary to write off assets on the basis of the replacement value, at a rate keeping pace with technical and economic evolution. A fact is that thus far, depreciation has been adjusted to a too long life of the object and consequently has been too low. Far too large a part of the railways has grown obsolete. Whereas road and air transport operate with very modern stock, the railways have still in their service rolling stock from 40 to 50 years old. It must be added that many lines are not suited for the speeds which modern stock can run, owing to the construction of the way as well as to the safety appliances. So it is not only a regular renewing that is involved but also the making up for important arrears in maintenance work.

9. Interest and dividend.

In general railways will have to be looked upon as national undertakings—their development leads to this.

If, however, traffic is continued to be looked upon as one whole—and this in absolutely necessary—these undertakings, in spite of their public character, will have to be conducted as commercial enterprises along with the others. Their management must be as keen and be allowed to be carried out as unhampered as is the case with their colleagues in other enterprises.

The question arises in the first place how large their capital should be and in what form it should be supplied. It would seem that the original capital should equal approximately the annual revenue. The great cyclical sensibility of railways renders it necessary for this capital to be invested in the form of shares.

This capital may have to be supplemented temporarily. Temporary circumstances may make extra capital essential, but such capital should not exceed about half of the capital stock.

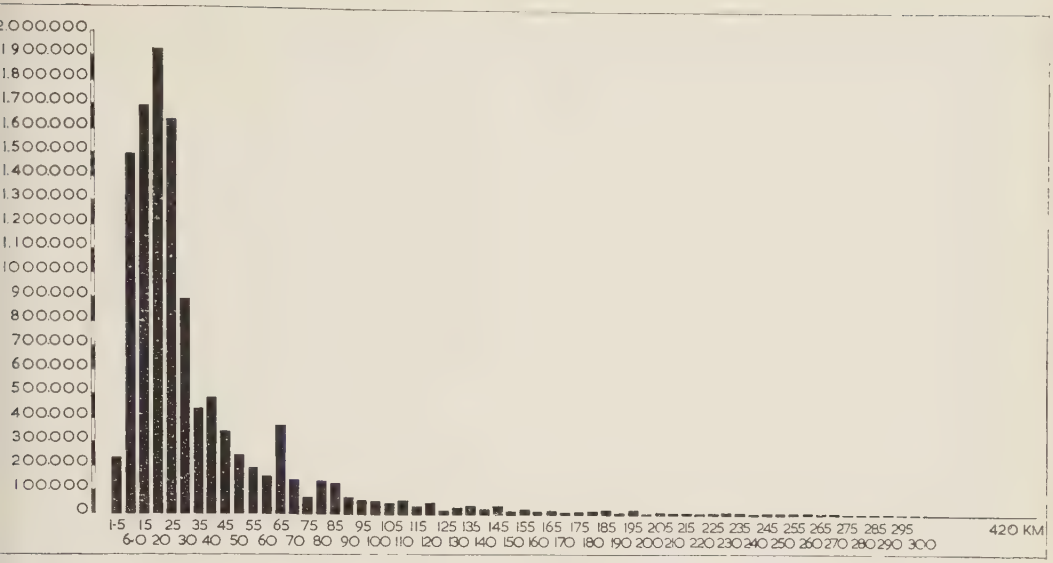
10. The technique of the equilibrium.

The striving after equilibrium between revenue and expenditure has consequently to be directed to both elements, but then always in relation to each other since they cannot be separated.

A high revenue can only be obtained with a well equipped and thriving enterprise. Consequently, besides the utmost restriction in the extent of the network and the number of the personnel, it is the equipment of the enterprise that matters.

A railway enterprise can be divided roughly into a part that has a permanent

(*) *Journal of the Institute of Transport*, Vol. 23, No. 8, January 1950.



Single tickets, return tickets, season tickets for juveniles, weekly tickets, monthly season and weekly season tickets : all reduced to single journeys. Total number : 11 603 028.

Figure 5. — Travelling distances : ordinary and short distance residential traffic.

character—the way, the yards (although the latter are also subject to alterations) -and into a part which has to be completely renewed within 25 to at most 40 years.

This part will certainly be no less than approximately half of the total investment. For the Netherlands Railways 1/25 part of this on the basis of the replacement value amounts to about 65 000 000 guilders. Of this amount the permanent way (with the safety appliances) and the bridges form 43 per cent. The rolling stock with the energy supply share in it for 51 per cent, while the remainder requires 6 per cent.

Often the rolling stock—spectacular as it is—is put strongly in the foreground. This is erroneous, however. Permanent way and rolling-stock are equally important ; one without the other is worthless.

Moreover it is evident that permanent way and rolling stock require considerable amounts of capital and this makes it necessary in the first place to plan well.

This planning has its results in the time-table, the medium through which the passenger and goods traffics are acquired.

The better (i.e. quicker, more frequent, giving good connexions in conformity with the need) the time-table, the more the traffic.

A good time-table, however, can be applied only by means of good rolling-stock and over a good track. This stock must satisfy the requirements demanded by the passengers, which are of a two-fold character resulting from the difference between long distance and short distance traffic.

The average distance covered by a passenger on the Netherlands Railways network, amounts to 39 kilometres. Predominating is the short distance passenger.

Eighty-five per cent of the passengers travel distances shorter than 60 kilometres. Only 15 per cent cover greater distances.

a. The permanent way

If the integral elements of the equipment are considered separately, it is in the first

place the permanent way with the yards that come up for consideration.

This complex is practically immutable; it is true that curves—though at enormous cost—are still improved, yards abandoned and other yards constructed but this is on a restricted scale compared with the whole —one of the disadvantages over against the easily shifting road—and air transport.

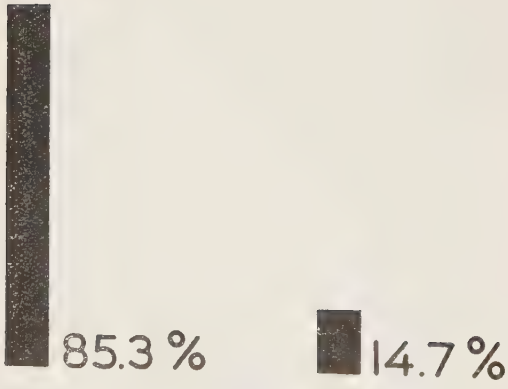
On what long terms and with what particular planning a railway undertaker has to proceed is very obvious here. Large works in this element of the enterprise will require separate financing and have to be looked at accordingly.

b. The superstructures

The amount required by the maintaining and renewing of the superstructure is enormous and almost equal to that of the rolling stock. Since it is practically impossible for arrears in the maintenance and renewals of the superstructure to be made up, they must be prevented by all means. A good superstructure is of advantage also for the rolling stock.

c. Safety appliances

To the permanent way belongs the regulation of the train traffic and the control of it. The way cannot be thought of apart from safety appliances and vice versa.



Regional traffic up to 60 kilometres. Traffic over 60 kilometres

Figure 6. — Netherlands Railways : Passengers.

Not less costly than the permanent way are the modern safety appliances and the question arises whether these costs can be met any longer.

It would seem that these costs will have to be decreased. This can be done in the same manner as for the permanent way, and in point of fact for the whole of the undertaking—by co-operation.

Diversity is perhaps even greater in signalling than in other parts of the enterprise. Also with regard to this point it is true that on the one hand the development must not, for uniformity's sake, be checked : on the other hand it must be possible for renewals to be carried out completely in a shorter period of time. If these renewals have to be restricted to certain station yards and sections, they are in fact unattractive, as with other departments of the undertaking, it will have to be considered too whether perfection is not being carried too far. This perfection leads to special complications, which under certain circumstances can create difficulties.

For the rest, protection (i.e. the safety appliances) must give especially « safety under all circumstances », and this makes the railways prominent among the four means of transport.

A good, modern railway must function punctually by day and by night, in snow and in fog and in all weathers. A well constructed and properly kept permanent way with good safety appliances are necessary for this purpose and consequently cannot be dispensed with.

d. Rolling stock

As with everything in the railway undertaking, the rolling stock has to be safe and strong. The working and the maintenance of the latter has to be simple, and comfortable and attractive for passenger, and suitable for goods.

So what is required is passenger rolling stock for the short distance which can be entered quickly, the interior of which can be surveyed at a glance in looking for a

seat, and which can be left quickly. This means carriages with wide doors and large platforms, of the coach type.

The passenger travelling over longer distances wants carriages affording more privacy, and therefore carriages with side corridors and compartments. In both cases uniformity whit great comfort is wanted.

From an operating point of view this uniformity is necessary as well. Besides this the trains will be required to be quickly and conveniently handled, quickly split up and made up. This requirement leads to « trains without locomotives », train units with automatic, central couplings.

The running of these train units, however, is less smooth—for the longer distances they do not satisfy and the hauled carriage is preferred. This fits in with the movement of the hauled vehicles. During the night there are the goods trains and a few passenger trains, and by day the trains over longer distances with, in between them, the very frequent service of the train units for the short distance traffic. Train units moreover restrict the track-requirements at the stations and in the yards.

A similar planning is necessary for goods traffic. Here too the need of quickly splitting up and making up is felt—trains for mail and express goods, by the side of the long distance trains between a minimum number of principal goods stations, from which the wagons are disposed of by means of local goods trains.

From this planning follows the type and amount of stock, with the normal and maximum speeds at which they must be run and, further, the whole equipment of the enterprise.

As to the setting of the task of this equipment, the principle must be adopted of simplicity, greatest possible uniformity, size, strength. This principle guarantees a minimum need of personnel and of reserve, and guarantees a maximum of safety.

. The railways are still too much inclined to diversity. It is a matter of course that improvements must be accepted and carried out, yet they will have to serve for longer periods so that it is for longer terms that railway managements will have to look ahead.

In this long-term view the « lightweight » stock, so much discussed at present, does not fit in. « Light-weight » stock corresponds to the motor bus and motor lorry. It is out of place on the railway and belongs to the public highway. The typical character of the railway does not allow of light constructions. Safety, comfort and smooth running require heavy constructions.

e. Buildings

Generally speaking, the buildings of the railways more so than the other structures of the undertaking, have lacked critical observation ; they are out of date and, therefore, extraordinarily expensive in working and maintenance.

To this must be added that the station buildings and the goods sheds have been fitted up with little efficiency for the handling of passengers and goods.

It must be very easy for passengers to enter a railway station and they must feel at home there. On their way to the trains—which must be short and easy—they must not meet with obstacles. The buildings must be fresh and also well lit in the evening.

Station buildings may have a great publicity value. The amounts which are written off on them for depreciation must be put to their benefit. Here too, an appearance must be created which, not at a single point but over the whole of the system, can make the undertaking attractive to the public view.

The same holds good for goods sheds in which the expensive handling of small lots must be improved.

In this field, though late, a new development has started. This is accompanied by a modernisation of the goods sheds which will have to be carried through energetically and generally.

All measures concerning the separate

parts of the undertaking are aimed at a restriction of the functions to such as without doubt belong to the railway, intensifying the efficiency and the utmost economy in personnel, stock and equipment, which, for the rest, must be modern.

So long as there is a shortage (naturally a very small one) of personnel and stock, the reorganised undertaking will give a good financial picture.

11. The military task.

In a view concerning the future of railways the military importance should not escape notice. This importance exists and will continue to exist always. To come up to requirements in this respect no other standards are necessary than those which after all will have to be applied to the future undertaking.

Military transport too needs modern railways that are in good condition as well. Here too simplicity, uniformity and reliability are first and foremost necessary.

Summary.

1. Transportation and therefore traffic must be looked upon as one whole.

2. It must be accepted that each branch of transport (water, road, rail and air) by virtue of its technical and so economic qualities has a part in it. Railways are as much necessary and indispensable as are the other three transport components.

3. By a « regulated » competition a further development of each of the components separately must permanently be be made possible.

4. In that development movements of traffic to each of the four transport branches will continue to take place.

5. No one of the components must be in excess or at least greatly in excess of what is necessary for the performance of its task.

6. Government interference is for the determination of the volume appropriate to each component necessary.

7. The conditions on which the undertakings of the four components work have as far as possible to be made equal for all of them.

8. The public transport undertakings must be conducted within the framework of the civil law.

9. They must be conducted on a commercial basis according to an equilibrium between revenues and expenses of the undertaking as a whole.

10. The relation between the railways and industry will have to be modified in conformity with the relation between road and air transport on the one hand, and the motor-car and aircraft industry on the other.

Conclusion.

There is a good future for those railways which know how to restrict themselves to their proper functions and consequently are willing to transfer to others what can be done better by them. That future will not only be good, but even better if the railways will keep themselves young, strong and adaptable.

In that case they will actually be what they now wish to be : a great contribution to the prosperity of their country.

[621 .133 .7 (44)]

The treatment of feedwater for the locomotive boilers of the S. N. C. F.,

by M. Marecat,

Ingénieur principal au Service Technique du Matériel et de la Traction de la S. N. C. F.

(Revue Générale des Chemins de fer, November 1948.)

In a note concerning the deposition of scale in locomotive boilers, published in the July-August 1943 number of the Revue Générale des Chemins de fer, *the formation of scale was discussed together with its effect upon the performance and maintenance of boilers.*

A second note appeared in the number for January-February 1946, dealing with the cause and prevention of corrosion.

Both accounts made reference to the internal treatment adopted by the S.N.C.F. to reduce scaling and corrosion.

The purpose of the present note is to show how the treatment was applied to the locomotives of the S.N.C.F. (Traitement Interne Intégral ARMAND or T.I.A.) and to describe briefly the apparatus employed and the method of control.

CHAPTER I.

BROAD OUTLINE OF THE TREATMENT.

Essentially the treatment comprises :

1) The introduction into the feedwater of a proportional amount of a solution compounded of several constituents, its composition being determined by the nature of the water.

This compound has the desired effect of reacting with scale-forming salts to produce non-adherent precipitates and salts which remain in solution.

It creates the conditions necessary for corrosion resistance, while the precipitates form an easily removable sludge.

The solution, which will be referred to here as the « compound » is fed in by a *dispenser* or « *doser* ».

2) Limitation of the salinity (1) of the boiler water and of its sludge content.

This result is achieved by means of a periodical purge effected by extraction (« blowdown ») *valves.*

3) Subsequent methodical supervision in order to ensure that the foregoing conditions are satisfied, with inspection of the boiler and analyses of the water to check the actual against the estimated results.

The addition of the compound to the feedwater may be made at the water crane or in the locomotive itself at the time of taking water. Each method has its advantages and its disadvantages.

The use of the water crane makes it possible to adapt the composition of the compound in perfect fashion to that of the feedwater, but on the other hand it involves the considerable modification of plant of varying complexity, dispersed over a wide area and poses delicate problems of personnel and handling.

It is in fact necessary to arrange accommodation at each site for the manufacture of the compound and its storage in casks, together with facilities for supply to the

(1) *Translator's note :* Total boiler solids.

distributor and the cleaning and repair of the latter.

Provision must also be made for analysis of the water as a check upon its composition.

Finally, if it is not practicable to make special modifications to the water crane or to duplicate the installation, all locomotives have to take treated water and this introduces difficulties in the case of locomotives not undergoing treatment.

Equipment of the locomotives themselves is simply done by fitting a doser to the engine, a much smaller matter than installing a water crane. The initial outlay is greatly reduced and freedom of choice is conserved in the allocation of engines for treatment.

Choice of the composition of the compound however is a more delicate problem since the engines take water at numerous points and the average composition of the feedwater will depend upon that of the water at each crane (which does not remain constant over a period of time) and upon the working of the engine, which largely determines the quantity taken at each point. Nevertheless the permanent control service set up at the depot has every facility for tracing irregularities and taking the necessary counter measures.

After having examined and weighed the advantages and disadvantages of the two methods the S.N.C.F. decided in favour of the second one which is indisputably more flexible and economical.

The viewpoint thus taken by the S.N.C.F. is different from that generally current in the U.S.A. (1) where, however, the treatment is not undertaken by the railways themselves but by private firms, most of whom prefer to add the reagents to the water before it reaches the crane.

Preliminary measures. — In his note to the *Revue Générale des Chemins de fer,* dated July-August 1943, M. ARMAND described the mechanism of scaling and pointed out that the deformation of boiler plates by expansion or any other cause tends to break and loosen old scale. Such fissures however do not develop sufficiently to cause flaking because they are immediately plugged and sealed by fresh deposits. Continuity of the coating is constantly re-established and the detachment of flakes is a rare occurrence.

While the T.I.A. treatment does not promote descaling it hinders the formation of fresh scale and so removes all impediment to the progress of fissures and the detachment of flakes. These latter may be of considerable size even in a boiler that at first sight shows little scale. They impede the circulation of the water particularly around the tubes and in the water legs; they are difficult to detect and remove, and are sometimes the cause of overheating or local collapse of the plates.

It is therefore preferable to start with a clean boiler, that is to say one that is newly built or has undergone a general repair, or in any case one that has been retubed. It is highly inconvenient to delay the setting up of a control centre while awaiting such operations and it has been found possible to take an engine over for treatment at a stage other than as indicated subject to preliminary descaling of the boiler by an acid treatment.

Descaling is effected by the use of a mixture of water and hydrochloric acid to which an inhibitor has been added (1).

(1) France and the U.S.A. are the only countries in which there exists any extensive organisation for the « integral » treatment of feed waters.

(1) The amount of acid to be used is regulated by an instruction based upon those of the former P.O. and Etat systems. It is determined from a chart which takes account of the specific gravity of the acid and the area of the surface to be descaled. Approximately four litres of acid at 22° B. are required to dissolve a deposit one millimetre thick and one square metre in area.

Continuous agitation is employed to maintain the reaction, during the course of which analyses are taken to check the efficacy of the mixture. This is renewed when its HCl content falls below the required value.

The acid breaks up the carbonates only, but as these are always present in considerable quantity even in sulphate scales, the latter are also attacked. With the carbonates removed, the sulphates fall away in large pieces which are removed first during the rinse and later during the subsequent washouts which are spaced at short intervals with this object in view.

Although acid descaling does not generally achieve the same degree of cleanliness as that of a boiler fresh from general repair, the results are good enough to ensure that after two or three months the same washout cycle may be adopted as for boilers subjected to water treatment after heavy or intermediate repair.

CHAPTER II.

APPLICATION OF THE TREATMENT. EQUIPMENT.

The following will now be discussed :

A. — Equipment of locomotives;
— dose dispensers;
— extraction (« blowdown ») valves;
— blowdown recorders.

B. — Distribution of the compound at the depots.

A. Equipment of locomotives.

The treatment calls for considerable accuracy in its application. The whole of the salts must be added to the feedwater in the proportions required to establish a certain state of equilibrium which simultaneously prevents scaling, corrosion and priming.

Steam locomotives do not lend themselves to continuous supervision by specialist personnel as is possible with stationary engines. It has therefore been necessary to devise some form of apparatus perfectly adapted to the special requirements, fully automatic and entirely dependable in operation.

The development of such apparatus was an important factor in the success of the treatment and the S.N.C.F. has given it the greatest care.

1) DOSE DISPENSERS (« DOSERS »).

As previously stated, the composition of the compound and the amount added vary with the average composition of the feed waters. It has been possible to determine the dosage from consideration of these two factors. However, for convenience in fitting up and in supervision we have endeavoured to hold the variation of the dose within rather close limits. In practice it lies between 400 and 600 cubic centimetres per cubic metre of water ([1]).

(a) *Dosage.*

Regulation of the dose is effected either by means of a *continuous feed device* (calibrated tube or orifice) or by means of *successive additions* each proportional to an accurately measured volume of water.

(b) *Distribution.*

The addition is made either directly into the tender when taking water or by introduction into the piping of the feedwater apparatus. There is clearly a number of solutions to the problem and numerous systems have in fact been proposed and tried.

The chief difficulties encountered derive from the nature of the compound which is a rather viscous liquid sometimes containing particles in suspension and which does not always pass easily through small orifices.

Again, the desire not to make an unduly large addition leads in certain cases to the use of a compound rich in dissolved salts. The crystallising temperature rises, sometimes exceeding 15° C. Apart from complete solidification, which is not likely either to occur or to pass un-noticed, it is possible that in the coolest places, which are frequently also the most critical, the

([1]) *Translator's note :* Approximately one pint to 220 gallons of water.

circulation may be impeded by partial crystallisation. Moreover, the formation of crystals and their subsequent return into solution gives rise to variations in the composition of the reagent as dispensed.

In order to overcome this, we resort to heating of the doser to a temperature above a fixed minimum which is a function of the degree of concentration of the compound. Nevertheless, the limitation previously mentioned remains troublesome with continuous feed dosers (1) or with those that serve a feedwater pump delivering in small quantities, and we have been led to abandon them.

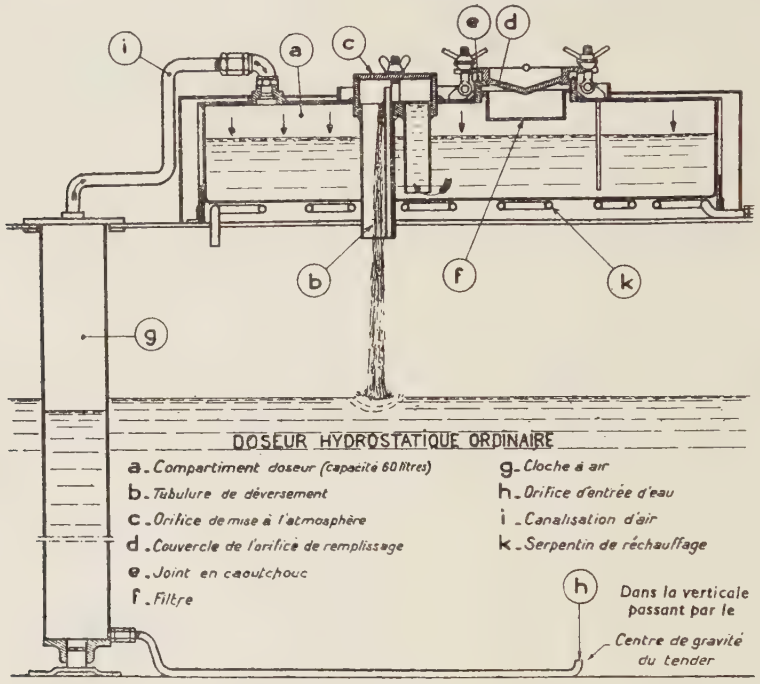

DOSEUR HYDROSTATIQUE ORDINAIRE
a - Compartiment doseur (capacité 60 litres)
b - Tubulure de déversement
c - Orifice de mise à l'atmosphère
d - Couvercle de l'orifice de remplissage
e - Joint en caoutchouc
f - Filtre
g - Cloche à air
h - Orifice d'entrée d'eau
i - Canalisation d'air
k - Serpentin de réchauffage
Dans la verticale passant par le Centre de gravité du tender

Fig. 1.

Explanation of French terms:

ORDINARY HYDROSTATIC DOSER

a — Dosage chamber (capacity 60 litres).
b — Discharge pipe.
c — Vent to atmosphere.
d — Filling cover.
e — Rubber joint.
f — Filter.
g — Air bell.
h — Water inlet.
i — Air pipe.
k — Heating coil.
(h) — Opening coincident with vertical passing through C.G. of tender.

— When the tender is filled, water rises in the air bell (g), expels air through the pipe (i) and compresses it in the upper part of the doser. Under the force of this pressure the compound flows from the chamber (a) into the tender by way of the discharge pipe (b) in proportion to the volume of air displaced. Syphoning is prevented by the vent (c)
— When the tender is emptied the fall of the water level in the air bell (g) lowers the pressure in the doser (a). Air re-enters the chamber as soon as the pressure falls below that corresponding to the height of the compound.

The hydrostatic doser so-called, which

(1) If the dose is 0.5 litre per cubic metre the cross section of the feed orifice must be approximately 1/2 000 of that of the air intake, that is of the order of one square millimetre.

was finally approved, is shown in figure 1. It dispenses successive additions directly into the tender or tank (1).

For reasons which will be apparent the delivery of the doser depends upon the amount of reagent in the dosage chamber. It falls away gradually as the latter is emptied and the full content of the chamber cannot in practice be utilised. The decrease is more noticeable with increasing capacity of the doser.

The double-compartment doser seen in figure 2 offers a partial solution to this difficulty. Its features are as follows :

— The doser is divided into two compartments, one being the dosage chamber and the other a reservoir.

— As the tender fills the pressure of the air displaced from the bell is applied to the dosage chamber only, forcing the valve on to its seat and thus interrupting communication with the reservoir compartment.

— The discharge is replaced by fresh reagent from the reservoir when, by reason of the lowered water level in the tender, the pressure in the dosage chamber falls below atmospheric.

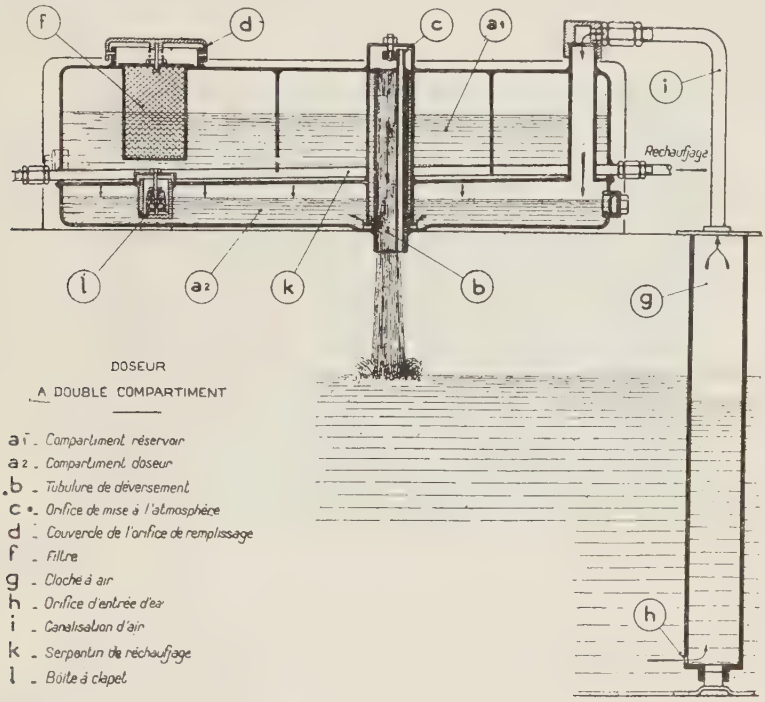


Fig. 2.

Explanation of French terms:

DOUBLE-COMPARTMENT DOSER.

a^1 — Reservoir.
a^2 — Dosage chamber.
b — Discharge pipe.
c — Vent to atmosphere.
d — Filling cover.
f — Filter.
g — Air bell.
h — Water inlet.
i — Air pipe.
k — Heating coil.
l — Valve housing.

(1) This type of doser was formerly used with the earlier liquid disencrustants.

— The apparatus has an effective capacity of 100 litres (instead of 60).

— The valve housing is placed inside the dosage chamber close to the heating pipe so as to lessen the risk of partial freezing.

Another variant, at present on trial, consists in using a device rather like a hydraulic valve to replace by an equal volume of air the whole of the compound fed into the tender.

It goes without saying that in all hydrostatic apparatus the air pipes must be absolutely airtight.

Heating the compound. — We have seen that the compound must be maintained above a certain temperature in order to avoid any crystallisation and to ensure satisfactory fluidity. It is therefore kept warm by a steam-heated coil.

In order to simplify the installation as far as possible the necessary steam is taken from the steam-heating pipe of the engine itself, when the train is not being heated, by a small bypass conduit.

It remains to adjust the steam supply to the exact amount required to ensure that the temperature does not drop too far during sharp cold or rise too far under normal conditions (1). This will be achieved by thermostatic control, the adoption of which has just been approved. The temperature will be held between + 15° and + 40° C.

Alternative type of doser.

For the sake of completeness, reference is made here to the type B doser (fig. 3) which is provisionally in use on engines fitted with lifting injectors.

This is a continuous feed device working off the feedwater supply and consequently subject to the limitations previously mentioned.

The principle of operation is as follows :

(1) This latter is no less troublesome. It is liable to cause decomposition of the compound and, by increasing its vapour pressure, to render the dosage erratic.

When feedwater is being taken the flow of water through the injector supply pipe produces a partial vacuum in the reservoir piping and draws off the compound. A diaphragm with a vent to atmosphere prevents syphoning of the compound after the injector is shut off.

The fact that the doser is fitted to the engine itself simplifies the heating of the reservoir.

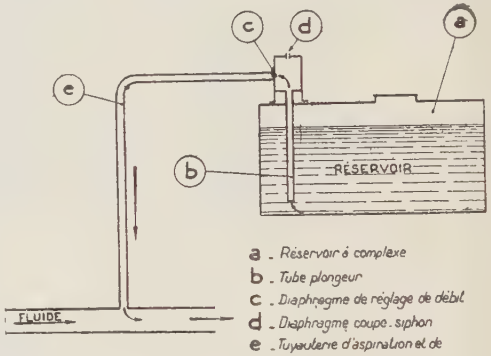


Fig. 3.

a — Reservoir.
b — Uptake.
c — Dose control diaphragm.
d — Anti-syphon.
e — Suction feed pipe.

2) EXTRACTION (« BLOWDOWN ») VALVES.

(a) *General considerations.*

The blowdown valve serves to draw off a certain quantity of water from the boiler, thereby lowering the salinity of the boiler water and reducing the amount of sludge.

When the weight of dissolved salts extracted, which increases with the concentration of the boiler water, becomes equal to that introduced by the feedwater, the concentration of the boiler water ceases to rise. Extraction at the rate of X per cent will result in a limiting boiler water concentration equal to $\frac{100}{X}$ times that of the feedwater, compound included (1).

(1) Cf. *Revue Générale des Chemins de fer*, January-February, 1946. ARMAND-PETIT, « Corrosion in locomotive boilers ».

The rate of extraction is therefore a function on the one hand of the composition of the feedwater and, on the other, of the maximum permissible salinity. In most cases it will lie between 5 and 8 per cent.

When blowdown valves were first fitted the question arose as to which was the more expedient, to draw water off while the engine is standing, or while running.

— Suburban service :

one blowdown of 10 seconds' in every 20 km;

— Shunting :

two blowdowns of 40 seconds equally spaced in each period of 8 hours;

— All services :

one blowdown of 60 seconds each time the engine returns to the shed.

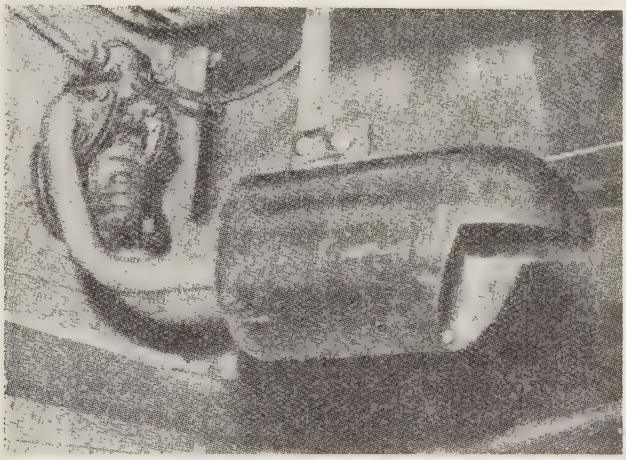


Fig. 4. — Assembly of blowdown valve showing extraction pipe and baffle.

A similar reduction in the amount of dissolved salts ensues in either case but the sludge is more readily evacuated when running with the regulator full open. When the engine is standing, practically the only sludge disturbed is that in the lower levels around the valve opening. On the other hand, when the boiler is hard at work the sludge is caught up by the intense circulation of the water and a much larger quantity is carried away.

Eventually, the following simple rules, aiming at a mean extraction rate of 6 per cent, were adopted by the S.N.C.F. :

— Main line service :

one blowdown of 30 seconds' duration in every 50 km;

In cases where check analyses show the extractions to have been insufficient the controller issues instructions for the number to be increased.

The blowdown valve is placed low down on the firebox, usually between the first and second rows of stays above the foundation ring (fig. 4).

(b) *Desirable features :*

First and foremost the valve *must be completely reliable in operation.*

A blowdown while running demands the attention of the engine crew and must therefore be of quite short duration. This entails a *high rate of extraction.* It should

be noted that the valve must be mounted *directly on the boiler* in order to prevent it from being choked by sludge.

Most of the valves fitted to our locomotives are of the type described as automatic.

occur in the event of the erratic application of pressure to the operating piston of the valve (1) a stop cock has been inserted in front of the 3-way cock and a small spring-borne automatic drain fitted above the piston (seen at [i] fig. 5).

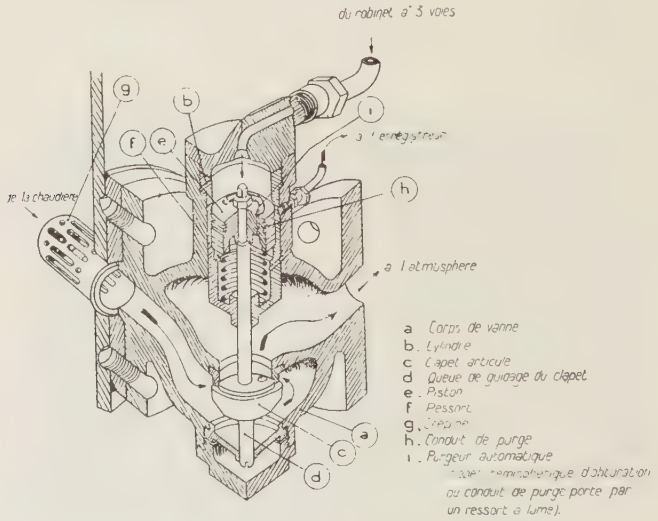


Fig. 5.

Explanation of French terms:
du robinet à 3 voies = from 3-way cock.
à l'enregistreur = to recorder.
de la chaudière = from boiler.

a — Valve body.
b — Control cylinder.
c — Articulated poppet.
d — Poppet guide.
e — Operating piston.
f — Spring.
g — Strainer.
h — Drain channel.
i — Automatic drain (hemispherical stopper to drain channel, held by leaf spring).

They are opened by steam (1) or compressed air (2) and close automatically when this pressure is removed, partly as the result of the boiler pressure acting against the poppet valve and partly due to the thrust of a spring.

The air or steam supply is controlled by a 3-way cock, operated by the driver.

In order to avoid mishaps such as would

The first blowdown valves failed on several occasions as the result of faulty closure of the poppet, due to absence of the strainer or of damage to it. A fragment of scale or metal had made its way into the valve and been jammed between the poppet and its seating.

In order to avoid such occurrences a number of safety devices were sought. The

(1) Customary in the case of valves made in France.

(2) As in « Okadee » valves fitted to 141-R engines built in the U. S. A.

(1) This valve was fitted to a considerable number of S.N.C.F. locomotives before the introduction of T.I.A., in connexion with earlier trials of disencrustants.

simplest appeared to be a hand-operated isolating valve which would prevent the escape of water even with the blowdown valve open. It was not without drawbacks. The ensemble was too elaborate and its working uncertain. It is in fact difficult to ensure perfect operation of a valve the stem of which passes through a gland that becomes fouled, especially when it is rarely used.

fact not one has been experienced among the 800 blowdown valves in service up to June 1st, 1948.

It is sometimes objected that a blowdown valve takes up valuable space at a point where it is usual to mount the blow-off cock. Some engineers have proposed a hand-operated blowdown that would serve as a blow-off cock as well, thus supplanting the latter. The valve is operated through a

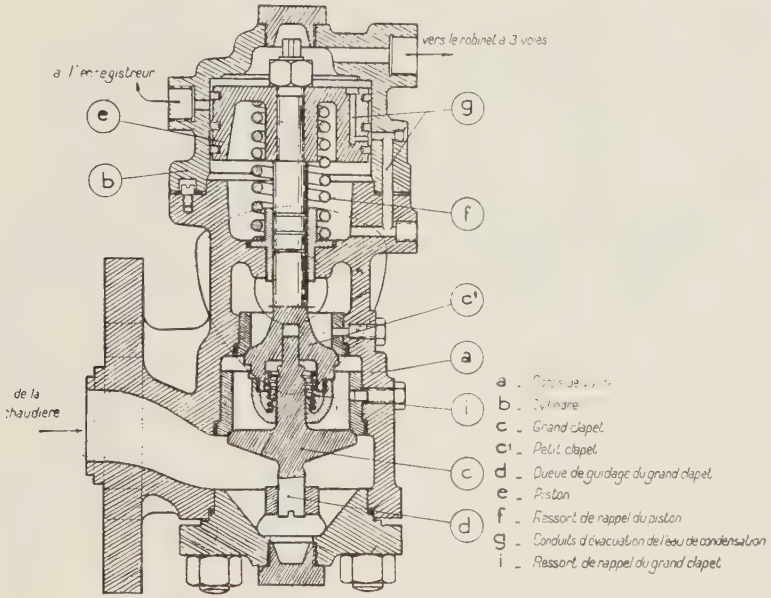


Fig. 6.

Explanation of French terms:

a — Valve body.
b — Control cylinder.
c — Large poppet.
c' — Small poppet.
d — Poppet guide.
e — Operating piston.
f — Operating piston return spring.
g — Drain channels for condensed steam.
i — Poppet return spring.

In the standard so-called double poppet valve (fig. 6) finally approved by the S.N.C.F. the water has to pass two poppets placed in series which the boiler pressure tends to close. In addition, the second poppet has a greater lift than the first so that any solid body passing the first must necessarily pass the second. The probability of failure becomes almost nil; in

plunger placed over the stem of the piston and actuated by a lever mechanism as in figure 7, which shows the fixture as fitted to the « Okadee » blowdown on the 141-R engines.

Before the introduction of T.I.A. a number of engines were provided with a hand-controlled valve operated from ground level, used for emptying mud pockets. These are of the well known « Cocard » pattern

(fig. 8) and are still used for blowing down when the engine is standing.

In order to complete this review, reference must be made to a special device known as the continuous purge (fig. 9).

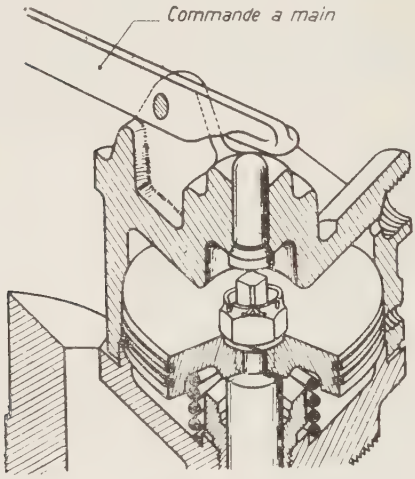


Fig. 7.

Explanation of French term:
Commande à main = Hand operating lever.

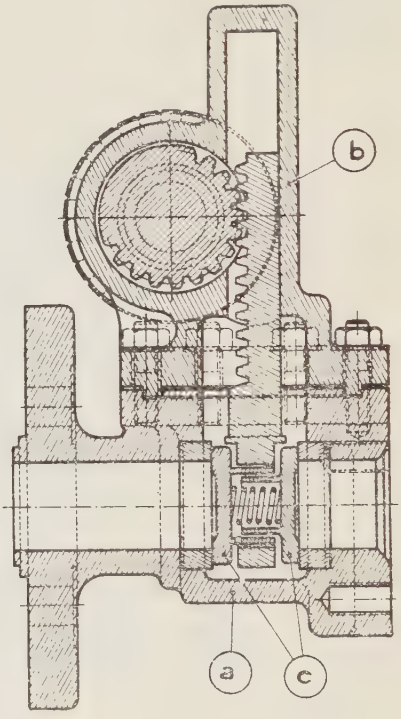
Deconcentration took place when the regulator was open, the quantity of water to be evacuated being drawn off through a calibrated orifice.

We hoped to avoid in this way the copious discharges of muddy water which tend to clog the ballast when blowing down occurs always at the same place (as when shunting) and to do away with the blowdown recorders required for checking the regularity of extraction, but numerous instances or defective operation were reported in service. The calibrated hole was frequently choked with mud despite automatic clearance by a needle at each closure of the regulator. Also small fragments of scale collected and were impossible to evacuate. The device had to be abandoned.

Maintenance of blowdown valves. — The valves are removed at each boiler washout, cleaned, briefly examined and checked on a test bench.

When the engine is called in for repair, all defects are noted and rectified in accordance with precise standing instructions.

Baffles. — The jet of water leaves the boiler under high pressure. If allowed to strike the ground it rebounds with violence, splashing all the lower part of the engine. Earth and stones are dislodged,



a - *Corps de vanne*
b - *Boîte à crémaillère*
c - *Opercules*

Fig. 8.

a — Valve body.
b — Rack.
c — Shutters.

surfaces which should be lubricated are wetted and water makes its way into the axleboxes. To overcome this it is necessary to fit a baffle to the end of the tube.

Several types have been proposed and tried. The device finally chosen by the S.N.C.F. is seen in figures 4 and 10.

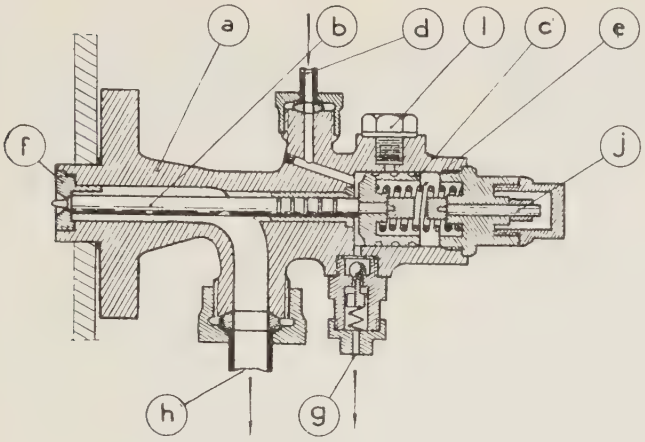


Fig. 9.

a — Valve body.
b — Valve.
c — Operating piston.
d — Steam inlet.
e — Piston return spring.
f — Valve seat.
g — Automatic drain.
h — Extraction pipe.
i — Grease cap.
j — Adjustable stop.

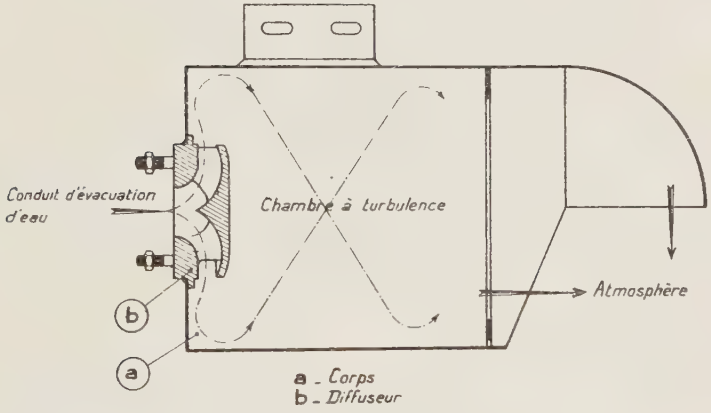


Fig. 10.

Explanation of French terms:
a — Body. b — Diffuser.
Conduit d'évacuation d'eau = Extraction pipe.
Chambre à turbulence = Baffle chamber.

3) BLOWDOWN RECORDERS.

The extractions are of such importance that it is indispensable to have positive proof of their regular observance.

With this in view, the S.N.C.F. first used a counter of the type represented in figure 11. This is a conventional drum recorder, driven by clockwork, which moves through one « unit » during every 10 seconds when released by the opening of the blow-down valve. In order to arrive at the total blowdown time during any given period it is sufficient to read off the number of 10-second units recorded by the counter.

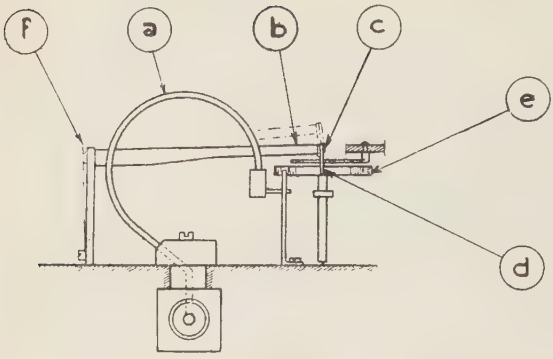


Fig. 11.

a — Manometric tube.
b — Lever.
c — Pallet.
d — Stop.
e — Balance wheel.
f — Tensioning spring for lever.

an additional piece of apparatus on the engine it was decided to record them graphically on the Flaman speed recorder. For this purpose we incorporated in the instrument an additional stylus linked by a stem to the diaphragm of a thermostat which is subject to the action either of the steam or air control of the blowdown valve or that of the water issuing from it. The thermostat is attached to the base of the recorder (fig. 12).

The pressure intake is usually a bypass from the blowdown valve, which is tapped either beneath the control chamber (displacement of the piston implies the opening of the valve) or in the water discharge pipe itself.

Figure 13 shows the type of record obtained.

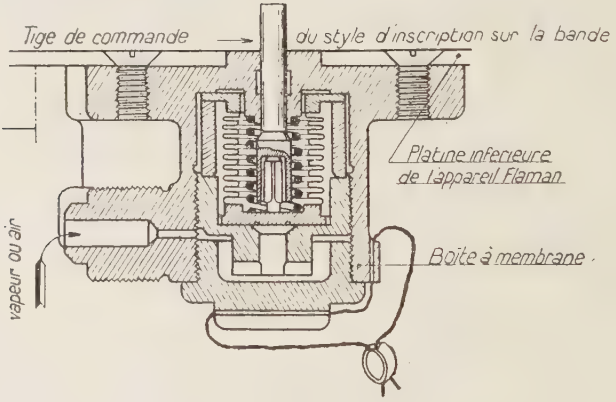


Fig. 12.

Explanation of French terms:

Tige de commande = Stem linked to recording stylus.
Vapeur ou air = Steam or air.
Platine inférieure = Base of Flaman recorder.
Boîte à membrane = Diaphragm housing.

The clockwork is set in motion only when the *stop* (d) *of the balance wheel* (e) is released.

This occurs when the tube (a) deforms under pressure and acting through the lever (b) lifts the pallet (c).

It was considered desirable to have a record of the times at which extractions were taken, and in order to avoid having

The length of each pulse seen near the time base shows the duration of a blowdown effected while running.

There is yet another type of apparatus (fig. 14) for use on engines not fitted with the Flaman recorder. This is an indicating and recording clock. A stylus, actuated by a diaphragm similar to that used in the Flaman instrument, records on a chart carried

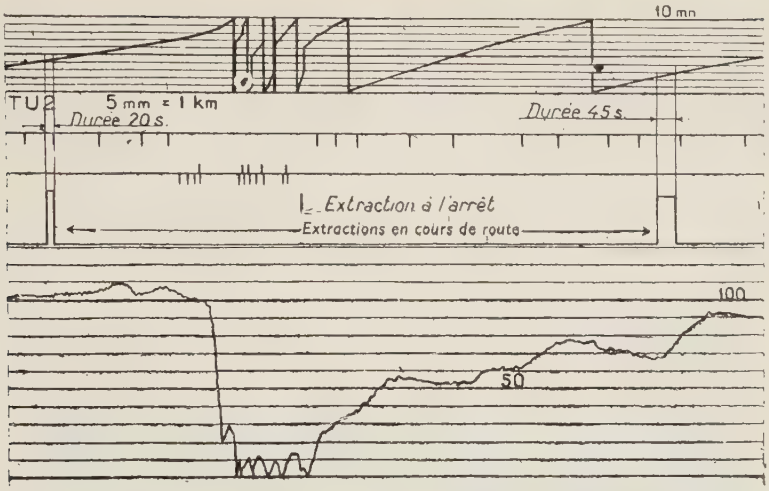


Fig. 13.

Explanation of French terms:

Extraction à l'arrêt = Blowdown while standing.
Extraction en cours de route = Blowdown while running.

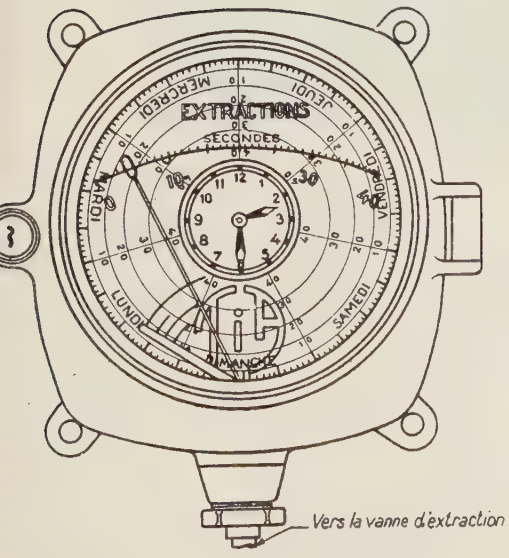


Fig. 14.

Explanation of French term:

Vers la vanne d'extraction = To blowdown valve.

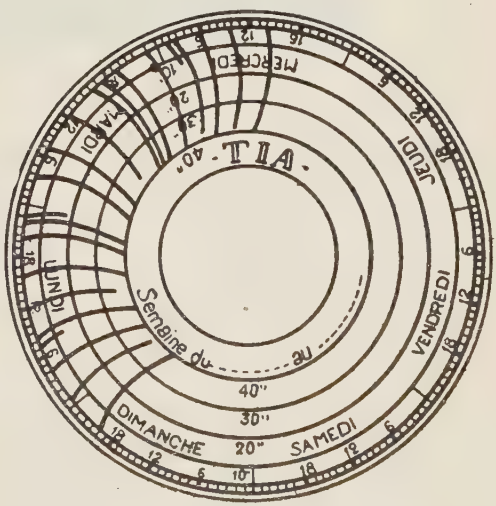


Fig. 15.

by a dial making one complete turn in seven days.

The stylus is engaged at the commencement of the blowdown and describes a circular arc proportional in length to its duration. A needle swings across another graduated dial and indicates the duration to the driver.

Figure 15 shows a chart from an instrument calibrated for 40 seconds.

head, or to the distributor piping if it is at ground level or below.

— The distributor ramp spanning the tracks to be served. At the right hand side of each track a flexible pipe branches off, terminating in a nozzle for insertion in the filling hole of the doser (fig. 16).

The plant is usually situated close to the roads by which engines enter the shed, near the sand bins and the inspection pits.

Fig. 16.

B. Distribution of the compound at running sheds.

The capacity of the dosers enables them to cover a journey of the order of 500 to 600 km without refilling, having due regard to the water consumption of the engine. They are therefore recharged when the engine returns to its home shed or at some intermediate point if the term of duty involves a journey approaching 500 km.

The filling station comprises :

— The stock reservoirs.

— The pump delivering the compound to the reservoir if this latter is placed over-

Supply from overhead tank (fig. 17).

In this arrangement the stock reservoir of about 2 000 litres capacity is placed high enough to feed into the ramp, which it does through a 3-way cock controlled either electrically or mechanically from each tapping point above the tracks. The slope of the conduit returns the unused compound to a recovery tank from whence it is pumped back into the reservoir.

Supply by electrical pumping unit (fig. 18).

An electric pump draws its supply from the bottom of the stock reservoir and delivers it to a distributor similar to that previously

described. The pump keeps the distributor charged and is operated by remote control, by the attendant responsible for filling the dosers. Any compound remaining in the distributor pipe returns under gravity to the stock tank when the pump is stopped.

Distribution from an overhead tank has certain drawbacks, in particular the need for fairly frequent attention to the 3-way cock, which involves the emptying of the tank. Also, the tank is generally outdoors and must be protected from frost, which means lagging it. Finally, an auxiliary tank is required to recover the compound that flows back from the distributor after each filling operation.

For the foregoing reasons, all future installations will rely solely upon electric pumps.

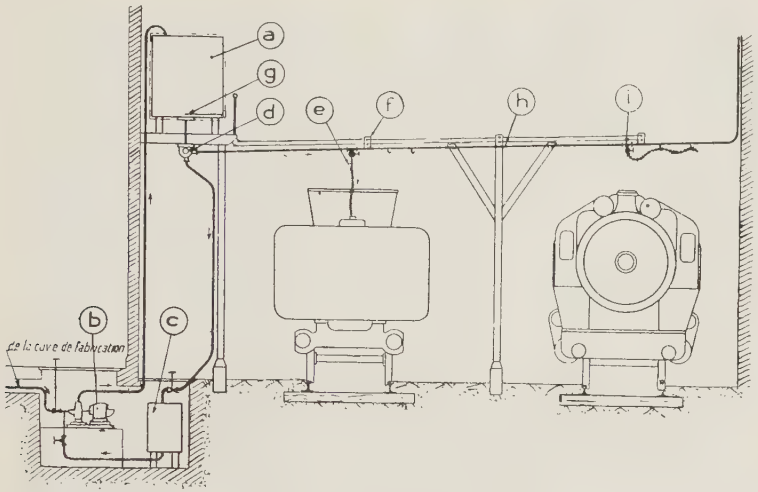


Fig. 17.

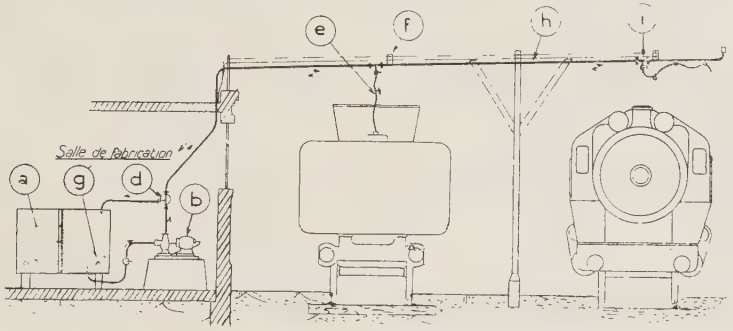


Fig. 18.

a — Supply tank, 2 000 litres.
b — Electric pump unit.
c — Recovery tank (not in fig. 18).
d — Electrically operated 3-way cock.
e — Flexible filling pipe.
f — Pres-button switch.
g — Immersion heater.
h — Distributor ramp.
i — Cock.
Salle de fabrication = Mixing room.

CHAPTER III.

CONTROL.

Despite the deeper investigation towards which the day-to-day problems are leading us, and the fact that further progress is still possible, the T.I.A. treatment may now be said to have been fully worked out. Whatever the nature of the water we know how to arrive at the composition and concentration of the compound and are able to lay down the procedure for treatment.

This however is only one part of the problem. Another, no less important, lies in supervising and checking the treatment itself. *This control is an essential feature. Upon its technical foundation, together with the experience of those who exercise it, success or failure may be said to depend.*

Contrary to what might be supposed, control is not limited to visual inspection at the time of washing out. The composition of the boiler water must be checked regularly, even if not in full, to make sure that the desired conditions are being constantly met. If they are not, an investigation must be undertaken without delay and its findings put into effect.

As previously stated, the maintenance of a state of equilibrium in the boiler is automatically followed by the complete cessation of scaling and corrosion.

Equilibrium is conditioned by :

(*a*) The nature of the raw water and of the added compound;

(*b*) The extractions,

and failure to maintain it even over short periods (up to three days) results in the immediate reappearance of the scale. The deposit may be thin, but it will not escape a practised eye. If this occurs repeatedly, scale will form and eventually give rise to troublesome flaking.

Control is shared among local, regional and central organisations (1).

1. *Local control.* — At each centre, there is a controller who where necessary has one or more specialist assistants, and who takes his orders from the chief of the establishment. He is responsible for the care of the boilers in locomotives undergoing treatment.

His chief duties are as follows :

— To supervise the preparation of the compound required for the locomotives at the depot. This is carried out by workmen under his instructions.

— To arrange for periodical samples of water to be taken from the treated boilers and to analyse them in the manner specified. Particular attention is paid to the T.H. (2) and the alkalinity.

For these purposes, he is provided with a small laboratory, which serves also as an office. This is fitted with a laboratory bench and the necessary apparatus such as flasks, burettes and beakers. There is a cupboard for reagents and spare glassware, a sink with running water, a table, a desk, a chair and a filing cabinet. One such laboratory is shown in figure 19.

The controller must in addition :

— inspect boilers jointly with the depot boiler inspectors at each washout;

— check the operation of T.I.A. equipment and arrange with the workshops for the necessary maintenance;

— make a daily check upon the working

(1) In addition to control, the central organisation is responsible for administration. It lays down procedure, decides which centres to equip, estimates the raw material requirements (some are on quota and others often difficult to obtain), places the requisitions and sees that the centres are suitably stocked. This task, while progressively lighter as we return to a more normal economy, has during the past few years been extremely onerous.

(2) *Translator's Note :* Soap hardness.

of water softeners at depots where these are installed (1).

From the results of the chemical analyses, from observations made when washing out, and the reports upon the equipment, the outs (2), follow maintenance work, and keep himself informed of the performance of engines undergoing treatment. Liaison with the workshops is of particular importance.

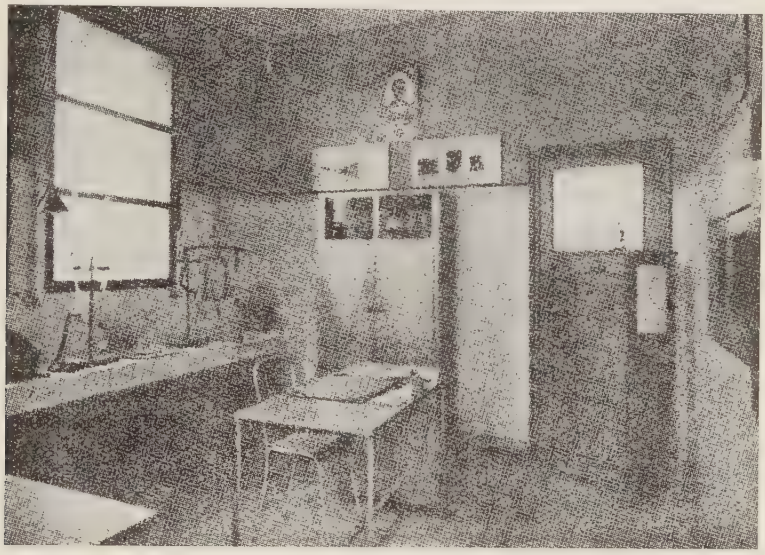


Fig. 19.

controller compiles a register giving particulars relating to each engine. Finally, he provides all departments concerned with reports and data enabling them to keep in touch with his activities and with the progress of treatment. In the event of any anomalous result that calls for the immediate attention of the Special Section, he communicates with them direct, at the same time notifying the local and divisional Motive Power Superintendents to whom they are attached.

The controller is of course in constant touch with the various departments at the depot in order to fix dates for the wash-

(1) The existence at each depot of a competent staff specially equipped to deal with water treatment, enables all branches of it to be under one man's hand. Practical experience has confirmed the wisdom of this arrangement.

(2) On the S. N. C. F. we make a point of compressing the maximum amount of running repair into the systematic periodic examinations which are made at certain fractions of the mileage between successive overhauls viz. : periodical examination under steam and when cold, at each 1/4 and 1/8; examination under steam at each 1/16 of the mileage.

It is therefore desirable to profit by the withdrawal from service occasioned by these examinations to arrange for washing out at periods spaced as follows :—

— 1/8 : Engines with high monthly mileage, treated when new or fresh from general repair, provided that the turn of service is completed in less than four months.

— 1/16 : Engines with medium monthly mileage treated after descaling, or not normally able to reach the 1/8.

— Submultiples of 1/16, at the rate of one or two washouts between each examination; engines doing low mileage, or freshly descaled. Engines not undergoing treatment.

Remarks.

(*a*) Boilermaking is one of the branches of technique in which experience is the most important factor, in which empiricism, tradition and custom are firmly established. The expected consequences of the treatment were likely to run counter to settled opinion, and some boilermakers might therefore be difficult to convince. Actually, and in contrast, once convinced they were to become ardent propagandists.

Moreover, knowing the defects and weak points of boilers, being able to follow the behaviour of their different parts in service, to observe the progress of erosion, cracking and corrosion according to the type of treatment, they were unquestionably in the best position to create a favourable atmosphere, to underline the advantages of T.I.A. and turn them to good account.

This has led us to recruit many controllers among one-time workmen and foremen in this craft possessing a certain amount of general knowledge.

This measure had the advantage of offering new prospects to some among the many tradesmen who had become redundant as the result of decreased employment among boilermakers. We thus made chemists of a number of boilersmiths who have in most cases given complete satisfaction.

(*b*) It might be supposed *a priori* that the controller's duties are simple, and that the methodical observation of directives and strict execution of orders received will suffice in all cases.

Without claiming that the supervision of T.I.A. treatment in a running shed calls for exceptional capability, it must be recognised that certain qualities are required in a good controller. One may be readily convinced of this by watching the various forms of activity that are called for.

Reference has just been made to the personal element.

From the technical standpoint the controller must be able to draw correct conclusions from his daily observations, decide upon the measures which result from them (which may be quite diverse) and distinguish among the current anomalies those which are within his scope from those which he must report. He must be capable of investigating the reasons for them and of deciding what action to take or propose.

In addition, being the representative of a new technique, he must profit by observation to widen his professional experience and to provide fresh data for the Special Section.

All this calls for the exercise of method, judgment, coherent thought and real initiative.

(*c*) The installation of a laboratory in a locomotive depot and its employment not for research or special trials, but for current service, is a noteworthy achievement since even less than ten years ago many would have judged it impracticable.

It provides a fresh illustration of the foothold secured by science in the workshop, a fresh example of the part played by the progress of science in lessening man's labour. When one considers the arduous and dirty nature of a boiler-maker's work, the progress from the social standpoint alone merits recognition.

2. *Regional Control.* — The Divisional Motive Power Departments are responsible for the application of T.I.A. at their depots. It is in the hands of an engineer or inspector assisted by controllers who visit the depots to see that the treatment is properly followed up and that it is giving the expected results. He takes all practical steps to correct any anomalous results due to the indifferent observation of instructions.

The district superintendent and his staff also assist in ensuring the correct application of T.I.A. in the sheds under his control.

3. *Control and research relating to water treatment on the S.N.C.F.* — This duty

devolves upon the Section for Research and Control, Water Treatment (« S.T.E. ») attached to the Technical Service, Rolling Stock and Motive Power.

This Section deals with the technical aspects of treatment in the different establishments. Its task is to study and develop the installations and apparatus indispensable to practical application, and to examine questions arising from the anomalies observed or reported to it by the regional departments or the local controllers.

Finally, it keeps the departments responsible for the maintenance of locomotives informed of the possible repercussions of water treatment upon the design and operation of the steam locomotive.

The S.T.E. maintains close contact with the running sheds through the frequent tours of inspection made by its representatives.

CHAPTER IV.

INCEPTION AND DEVELOPMENT OF WATER TREATMENT ON THE S. N. C. F.

Among other measures for combating the baneful influence of scale and corrosion upon fuel consumption and boiler upkeep, the former French Railway Companies had experimented with and used numerous disencrustants. The results varied considerably but were never very satisfactory and the cost of boiler maintenance always represented an important proportion of the operating costs of the former systems.

That is why, some months after the formation of the S.N.C.F. the Central Service for locomotives and rolling stock decided, under the impulse of its Manager, to pursue the question of water treatment on a national basis. The important investigation was entrusted to a Commission under the chairmanship of M. Armand, at that time Motive Power Chief Engineer for the South-Eastern Region.

The steel firebox had just been approved by them as a standard and the possibility of its more widespread adoption was to depend upon the successful outcome of the work of the Commission.

The Commission commenced by classifying according to their behaviour all the various disencrustants previously in use and drew up a test programme designed to enable them to form an exact estimate of the value of each one and of the results to be expected in practice.

This programme which had just got under way when war broke out, had to be abandoned after the armistice.

At the same time a methodical and scientific study of the phenomena of scaling and corrosion in boilers had been undertaken by the S.N.C.F. laboratories, under the guidance of MM. Armand and Petit.

These studies made it possible to define the conditions which must be fulfilled by an internal integral treatment, to make plans for carrying it into effect and to determine the nature and amount of the reagents to be used.

In this way originated « T.I.A. » the first trials of which, made in October 1940 at the Avignon depot, were sufficiently conclusive for the S.N.C.F. to decide in 1941 to treat the engines at Laroche (South-Eastern), La Rochelle (Western), La Villette (Eastern), les Joncherolles and Somain (Northern), where the poor quality of the water was the cause of frequent boiler repairs.

The application of the treatment was progressively extended and at the beginning of 1944, when the Allies commenced their air attack upon French territory, some fifty centres had been set up and about 1 600 specially fitted locomotives were running in regions where the quality of the water differed widely.

The results recorded from the very beginning also served to overcome certain prejudices among staff who, in view of the setbacks experience when using the numerous products tried earlier, no longer believed in the possible efficacy of a new procedure. Finding that they really had

« something new » they yielded to the evidence and quickly appreciated the value of the tool at their disposal.

Thus, during the occupation, considerable experience was gained, the economics

programme was drawn up, providing for the construction (or reconstruction) of the plant and the ordering of the equipment (stationary and running).

Everybody understood that the expen-

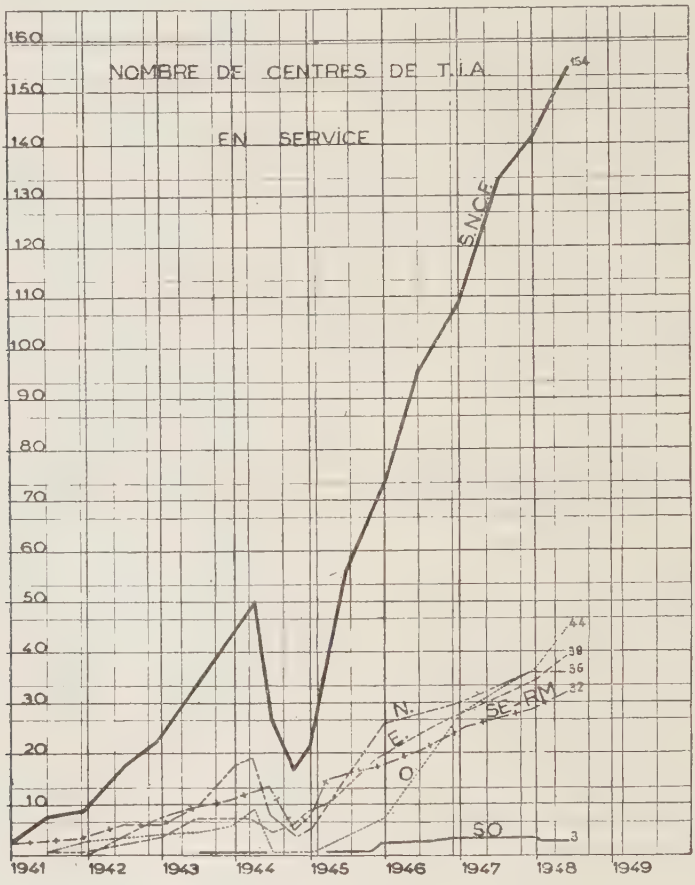


Fig. 20.

Explanation of French terms:

Nombre de centres de T.I.A. en service = Number of T.I.A. centres in operation.

were known, special staff were trained and the engine crews had been impressed with the necessity for blowing down.

Immediately after the liberation we entered upon the active phase. A complete

diture incurred would be quickly offset by the saving on locomotive repairs, while there would be at the same time fewer engines stopped for attention in the sheds. The local departments, well co-ordinated

by the Regional Services and the Water Treatment Section, displayed a lively spirit of initiative and their work soon bore fruit.

From September 1944 onwards, despite difficulties of every kind (1) the gear was repaired, new engines were equipped, damaged plant was put to work again and new centres set up.

The number of T.I.A. centres and of treated locomotives which as a result of the war had been reduced to 12 and 250 respectively in September 1944, rose rapidly until in May 1945, eight months after the liberation, it was the same as at the beginning of the bombardment.

Recovery continued at a rate such that at June 1st 1948, most of the depots at which treatment had been considered necessary were provided with a water treatment

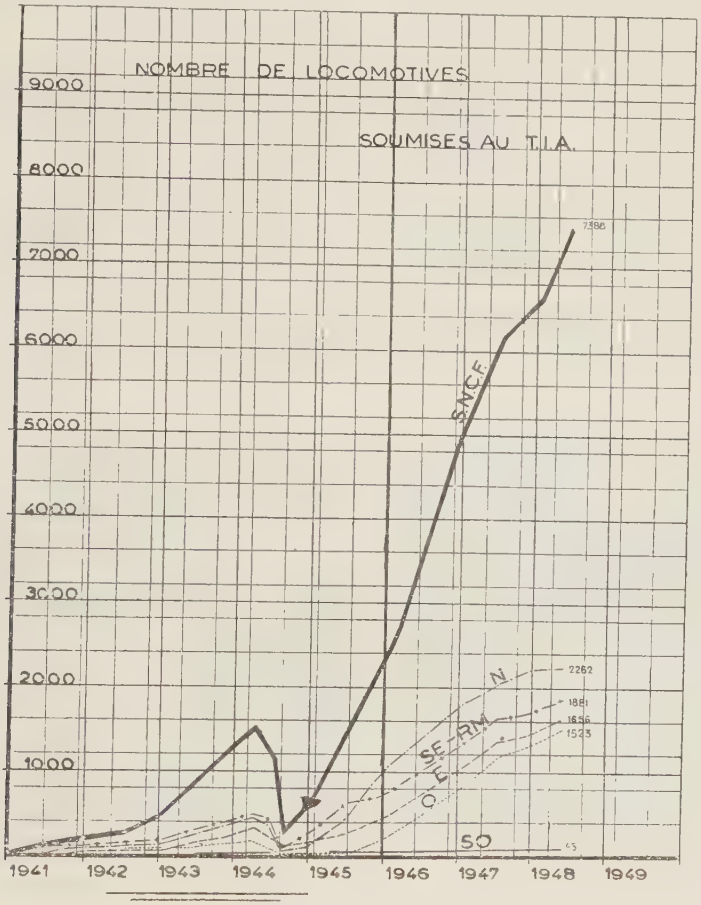


Fig. 21.

Explanation of French terms:
Nombre de locomotives soumises au T.I.A. = Number of locomotives undergoing treatment.

(1) Shortage of trained staff, of raw materials for plant and for the preparation of the compound.

centre, and more than three fourths of the total number of engines were undergoing treatment.

The entire installation covering about 9 000 engines will be completed within a year from now.

The graphs (figs. 20 and 21) show the progress of the application of T.I.A. from the trial stage up to June 1st 1948.

In conclusion, we should like to pay tribute to the response of which the French railwayman is capable when both management and staff are animated by a common desire, and to the team spirit which brings forth all the resources at his disposal — ardour, initiative and the determination to see the job through, in which there is also seen a certain spirit of emulation (1).

Many establishments have made a great point of seeing that their quarters were clean and well arranged, even elegant, according to the character and possibilities of each. What contrast there was in many cases between a T.I.A. installation and the frequently gloomy, unattractive appearance of an engine shed, particularly when it was but newly retrieved from its ruins!

(1) We are bound to cite, here, as perfectly personifying this spirit, Divisional Inspector POTTIER, who was entrusted with the application and development of T.I.A. from 1940 onwards, and whose competence and enthusiasm were a magnificent example. His devotion to his country was of the same order. As a member of the resistance he was arrested by the Germans on June 24, 1944, and deported to Germany where he died at Ellrich on February 27, 1945.

[621 .431 .72 (73) & 625 .28 (73)]

Economics of Diesel-electric multiple-unit trains,

A study of the possibilities of improving suburban type passenger service with a reduction of operating expenses,

by H. Bleibtreu,

Consulting engineer, Research and Development Division, Pullman-Standard Car Manufacturing Company.

(*Railway Age, April 22, 1950.*)

Passenger service of Class I railroads was operated in 1948 at a deficit of $559 million. The loss is mainly attributable to the relatively short runs, to branch line trains, and to the increasing diversion of traffic to buses, private automobiles and airways. While great efforts have been made to improve the efficiency of motive power, even the Diesel-electric locomotive, successful as it has been on long-distance hauls, fails to be a complete cure. Nothing short of a profound change in the technological structure of local, branch-line and suburban hauls will enable the railroads to operate passenger service at a profit. Here the Diesel-powered motor train offers definite possibilities.

The passenger locomotive — steam or Diesel — is at its best at the head of a long, heavy train.

Motor trains, in the sense intended in this article, must not be confused with the self-propelled cars of the Twenties (« doodle bugs ») or with motor trains of the early « Zephyr » variety with head-end locomotive-type Diesel engines. Motor trains as treated in this article are trains which have no locomotive, which can run in either direction, and which consist of 2 to 10 or more cars, some or all of which are equipped with individual power plants. These cars, called power cars in contrast to the non-powered cars, called trailers, are under remote control from the driver's cab at either end of the train by means of a low-voltage cable running the entire length of the train. The combination unit of

power cars and trailers is equipped with driver's controls at each end as in electric suburban trains.

Fields of motor trains.

The power plants are « packages » similar to those of buses, and the power cars contain seats up to the full capacity of ordinary coaches. Customarily, motor trains consist of one or several two- of three-car units. A two-car unit includes a power car and a trailer or, more seldom, two power cars. A three-car unit consists either of two power cars with a trailer in the middle, or of one power car and two trailers, the power car being either in the middle or at one end.

The motor train is the ultimate fulfillment of the most distinctive characteristic of Diesel power—namely, its decentralization into a multiple of highly efficient small and independent, yet centrally controlled units.

Motor trains can be considered for local and interurban service on main lines ; for branch-line trains, where they may be cut off from and joined again with main-line trains, thereby providing fast and convenient direct connections between large cities and smaller communities along secondary lines ; and for suburban service. Of these three operations, the last presents the greatest problem in justifying expenditures for new equipment, and will be used as the example for this discussion. Even in the commuter field, however, where a return on an investment is most difficult to realize, it can be shown that the motor train is a profitable investment.

Multiple-unit train service need no longer be confined to electrified lines.

The nature of the problem.

Suburban passenger service is, as a rule, an unprofitable yet an important business. According to Association of American Railroads, suburban commuter service accounts for almost 50 per cent of all passengers carried and nearly 18 per cent of the total passenger-miles of Class I railroads.

The rapid development of residential suburbs and of industrial reservations along the outer edges of large cities confronts existing suburban lines with the problem of providing fast and frequent service, and may also necessitate the extension of pas-

senger transportation to the existing freight-carrying belt or loop lines to create fast connections between residential and industrial areas at the city outskirts.

Boulevards and superhighways are certainly indispensable supplements to the suburban train, but neither the private automobile nor the bus will be able to replace its large seating capacity and its fast and dependable service.

With a rush-hour sequence of a train every five minutes, and seven cars per train with 85 seats per car, the throughput is over 7 000 passengers per hour. To carry the same load, 175 buses of 40 seats each would be required per hour, and they would have to follow each other at the short interval of 20 seconds. Even on superhighways with a limited number of stops a frequency of this magnitude would be incompatible with economic, fast, punctual and safe transportation. Moreover, a further increase of automobile and bus traffic would aggravate the congestion and the parking problems of the inner cities still more.

Under these conditions, the railroads are confronted with new and far-reaching problems, which go far beyond minor and sporadic improvements of existing equipment. One of the most important questions is : steam, electric or Diesel motive power ?

Electrification the ultimate goal.

The drawbacks of steam power are high standby fuel losses, high maintenance costs because of the age of most locomotives, smoke and cinder nuisance, and often long non-revenue trips from and to roundhouses. Favorable points are that most steam locomotives have been written off and that many of them are former rather powerful road locomotives, which maintain schedules that are hard to better even with modern Diesel locomotives. Because of these factors, steam locomotives cannot yet be dismissed completely from future plans. Falling residual fuel oil prices may also make practical the conversion of coal-burning locomotives to oil burners, which will partially overcome most of the principal present disadvantages of steam suburban power

Electrification is the ideal solution and must remain the final goal. It requires heavy investments, however, and can be justified only where high traffic densities prevail also during off-peak hours. Looking ahead, we must remember that (a) recent developments of electric conversion equipment abroad hold out hope for considerable reduction of first costs ; and (b) the frequent schedules economically obtainable by electric trains are helpful in developing the served territory, so that with increasing traffic density incipient losses may change into profits.

Diesel-electric power may be considered a compromise between steam and straight electric power in both cost and desirability of traction characteristics. It can be applied in either of two forms, independent locomotives or motor trains. The two types of the former that are presently available and being applied to commuter service are the 1 500 HP road switcher and the 2 000 or 2 400 HP main-line locomotive, the characteristics of both of which are well known.

Characteristics of motor trains.

The motor train is the second form of Diesel traction and has certain operational advantages over steam or Diesel locomotive-powered trains, including (a) ability to run in either direction, resulting in less switching, less congestion and quicker dispatch at terminals and coach yards ; and (b) divisibility into two or more independent units, resulting in flexibility and adaptability to traffic fluctuations, and also permitting more frequent schedules.

Economic advantages include :

1—Fuel saving up to 25 per cent, due to smaller train weights.

2—Saving in first costs up to 30 per cent and more, depending on the percentage of old coaches which must be replaced due to their obsolescence (a power car replaces an old coach anyway.

TABLE 1. — **Expense comparison of steam, Diesel loco**

Lines	Consist	Unit weight	Train-miles per day	A Light weight, tons	B Numbers of seats	C Full weight, tons	D HP per ton (full wt)	E First co
1	5 locals (4 round trips) (steam and 3 old cars)	Loco. 190 t Car 55 t	1 200	355	288	377	5.8	5×3× $ 2 = $ 300
2	5 expresses (1 round trip) (steam and 6 old cars)	—	300	520	576	563	3.9	5×6× $ 2 = $ 60
3	5 expresses (1 round trip) (steam and 9 old cars)	—	300	685	864	750	2.9	5×9× $ 2 = $ 90
3A	*Totals for steam operation*	—	—	—	—	—	—	$ 1 80
4	5 locals (4 round trips) (1 500-HP. Diesel and 3 old cars)	Loco. 120 t Car 55 t	1 200	285	288	307	4.9	5×3× $ 2 +5× $ 15 = $ 1 05
5	5 expresses (1 round trip) (1 500 HP-Diesel and 6 old cars)	—	300	450	576	493	3.0	5×6× $ 2 +5×$ 15 = $ 1 35
6	5 expresses (1 round trip) (1 500 HP Diesel and 6 double-deck cars)	—	300	450	852	513	2.9	5×6×$ 1 +5× $ 15 = $ 4 05
6A	*Totals for Diesel locomotive operation*	—	—	—	—	—	—	$ 6 450
7	5 locals (4 round trips) (1 1 000 HP power car and 2 old cars)	Power car 76 t Old car 55 t	1 200	186	279	207	4.8	5×2× $ 2 +5× $ 16 = $ 1 02
8	5 expresses (1 round trip) (2 1 000 HP power cars and 4 old cars)	—	300	372	558	414	4.8	5×4× $ 2 +5×2× $ 165 000 = $ 2 05
9	5 expresses (1 round trip) (2 1 000 HP power cars and 7 old cars)	—	300	537	846	601	3.3	5×7× $ 2 +5×2 $ 165 = $ 2 35
9A	*Totals for motor-train operation*	—	—	—	—	—	—	$ 5 425

otor train operation in a suburban system.

F	G	H	I	K	L	M	N
	Maintenance expenses						
uel . oil nd ater	Loco's or power cars	Non-powered cars (At $ 0.03 per car mi.)	Engine-house expense	Switching expense	Operating expenses (F+G+H-+I+K)	Capital investment costs	Total costs (L+M)
$ 0 385 co. mi.) 8 500	(At. $ 0.33 per loco. mi.) $ 118 800	$ 32 400	(At. $ 0.151 per loco. mi.) $ 54 400	(At. $ 4.00 per 30 loco. mi.) $ 48 000	$ 392 100	$ 30 000	$ 422 100
$ 0.358 co. mi.) 2 200	$ 29 700	$ 16 200	$ 13 600	$ 12 000	$ 103 700	$ 60 000	$ 163 700
$ 0.414 co. mi.) 7 200	$ 29 700	$ 24 300	$ 13 600	$ 12 000	$ 116 000	$ 90 000	$ 206 800
7 900	$ 178 200	$ 72 900	$ 81 600	$ 72 000	$ 612 600	$ 180 000	$ 792 600
$ 0.069 n mi.) 6 300	(At. $ 0.225 per loco mi.) $ 81 000	$ 32 400	(At. $ 0.05 per loco. min.) $ 18 000	(At. $ 3.00 per 30 loco. min.) $ 36 000	$ 243 700	$ 105 000	$ 348 700
$ 0.04 n mi.) 7 800	$ 20 300	$ 16 200	$ 4 500	$ 9 000	$ 67 800	$ 135 000	$ 202 800
$ 0.04 n mi.) 8 500	$ 20 300	$ 16 200	$ 4 500	$ 9 000	$ 68 500	$ 405 000	$ 473 500
2 600	$ 121 600	$ 64 800	$ 27 000	$ 54 000	$ 380 000	$ 645 000	$ 1 025 000
0.069 n mi.) 1 400	(At. $ 0.19 per car mi.) $ 68 400	$ 21 600	(At. $ 0.06 per power-car mi.) 21 600	—	$ 163 000	$ 102 500	$ 265 500
$ 0.04 n mi.) 4 900	(At. $ 0.19 per car mi.) $ 34 200	$ 10 800	$ 10 800	—	$ 70 700	$ 205 000	$ 275 700
$ 0.04 n mi.) 1 600	$ 34 200	$ 18 900	$ 10 800	—	$ 85 500	$ 235 000	$ 320 500
7 900	$ 136 800	$ 51 300	$ 43 200	—	$ 319 200	$ 542 500	$ 861 700

3—Because of fewer axles, an eventual saving in maintenance costs.

4—Eventually equal and smaller servicing costs, provided that servicing procedure is similar to that of bus barns.

5—Eventual elimination of the fireman as on electric suburban trains or on buses.

Technical status of motor trains.

Motor trains offer no major engineering problems any more. They have been widely used in Europe for many years. There is no reason why properly designed motor-train Diesels should be less reliable than those of buses and locomotives. At present, American-built Diesels usable on motor trains do not exceed 500 HP (continuous load), while 650 HP capacity, obtained in European motor-train Diesels for many years, is desirable.

Electric transmissions are thoroughly matured, while hydraulic torque converters have recently made such strides that their satisfactory operation appears assured. Vehicle, power plant, transmission and controls form an integrated organic unit. The old mistake of « throwing together » ordinary coaches and power plants with little regard for their integration has been the main reason for previous failures.

Economics of motor trains.

To appraise the various factors favoring one or the other of the three forms of motive power—steam, Diesel or motor trains—an example will be assumed, which, although hypothetical, is representative of the prevailing suburban systems around larger cities. The assumed system contains the following trains :

1—Five locals of three cars and 300 seats each, which make four round trips of 60 miles between 6.00 a.m. and midnight; the average distance between stops is one mile.

2—Five expresses of six cars and 600 seats each, and another five expresses of nine cars and 900 seats each. These ten trains make only one round trip of 60 miles during rush hours and lie idle in between. The average distance between stops is five miles.

Table I shows the consists and the annual costs (without crew wages) of the 15 trains. In case of steam operation (lines 1 to 3) there are 15 old Pacific-type (4-6-2) locomotives and 90 cars of 96 seats each. All this equipment has been written off, except that for each car $ 20 000 for reconditioning has been assumed.

For the Diesel locomotive trains (lines 4 to 6), 15 road switchers of 1 500 HP, each costing $ 150 000, are employed. For each of the old coaches retained, $ 20 000 is assumed for reconditioning. As a 1 500 HP locomotive is unable to maintain schedules with nine old coaches, they must be replaced by six new double-deck cars, each having 142 seats and costing $ 110 000 (line 6). If, instead, 2 000 HP Diesel locomotives were used, four double-deck cars and three old coaches would be needed.

Motor trains offer a choice of several combinations. Assuming two basic Diesel-generator sets as package units, one with a V-type engine of 500 HP and the other with a horizontal engine of 250 HP the following choices exist :

Power car with 500 HP with one V-type engine mounted in the cab at one end, or with two 250 HP flat engines mounted under the floor.

Power car with 1 000 HP with a V-type engine at either end, or with two V-type engines mounted side by side at one end with a 2 ft. 6 in. passage between.

The V-type engine can be removed through the roof or the sides of the car as a package together with the generators. The auxiliary equipment such as radiators and fans are also mounted as subassemblies or packages, so that a power car can be easily converted from a 500 to a 1 000 HP unit and vice versa.

In the present case a power car of standard weight was chosen with a buffing

strength of 400 tons and with two 500 HP Diesel-generator sets mounted side by side. All four axles have traction motors. The car has a light weight of 76 tons, contains 87 seats, and costs $ 165 000. As seen from Table 1, lines 7 to 9, 25 such power cars and 65 old coaches are needed, the latter to be reconditioned at $ 20 000 each. A power car and two coaches form a three-car unit. It has a driver's stand at each end and can run in either direction. One such unit forms a local, two form a six-car local or express, while a nine-car express is formed by two three-car units and three old coaches in between. As the power plants are at both ends, a clear passage through the whole train is obtained, and the passengers do not come in contact with the engines.

Based on actual performance.

The operating expenses of Table 1 are based on actual performance statistics from a number of steam—operated suburban systems. The fuel consumption for Diesel power was obtained by well established scientific methods of traction dynamics. While the fuel consumption per ton-mile of motor trains is slightly higher than that of Diesel-locomotive trains, the latter are burdened by additional switching mileage, so that the fuel per revenue ton-mile is about the same in either case. The maintenance expenses of 19 cents per mile for a 1 000 HP power car as against 22.5 cents per mile for a 1 500 HP locomotive have been obtained by a careful analysis of reliable performance data of bus Diesels and foreign motor-train Diesels, making in the latter case due allowance for American conditions. In both cases an average age of five years was assumed.

Looking at the totals (lines 3A, 6A and 9A, column L, of Table I) it will be seen that Dieselization, either in the form of locomotives or motor cars, effects considerable operating savings over steam. At the same time these savings are more than wiped out by the high capital investment charges of Dieselization (column M), so that the total costs, when all 15 trains are considered (column N, lines 3A, 6A, 9A) are lowest for steam and highest for Diesel locomotives, with motor trains in the middle. This would indicate that Dieselization of the entire system cannot be justified on economic grounds alone.

But this is not the complete story. There are a number of factors which must now be taken into account and which will reveal that under certain conditions at least a partial Dieselization may be justified. We consider, therefore, the following four cases :

Dieselizing the local trains.

Case I—Assuming that only the five locals of Table I be Dieselized, column N, lines 1, 4 and 7, indicates definite savings by Diesel locomotives, and still more so by motor trains. Transferring the pertinent figures of these lines to Table 2, lines 1, 2 and 3, shows that the return on the investment spent in excess of that needed in the case of steam operation is 9.8 per cent for Diesel-locomotive trains and 21.6 per cent for motor trains. If the Diesel locomotives can be used at night for other purposes, only one-half of the annual capital investment charges of any locomotive thus used, or $ 7 500, will be chargeable to suburban service. To break even with motor train operation, line 3, column P, 83-200/7 500, or 11 Diesel locomotives must find employment at night. As there are only five locomotives, it is obvious that motor trains remain more economical than Diesel locomotives.

Case II (a)—Because of the faster dispatch of motor trains the number can often be reduced. As one example, the locomotive train makes the roundtrip in four hours (two hours running time plus one hour at each terminal for unloading, backing out, switching, backing in and loading) as against three hours for the motor train (two hours running time plus ½ hour at each terminal for loading and unloading). Three motor trains can then do the work

TABLE 2. — **Annual dollar expense o**

Lines	A Cases	B Train consists	E First costs	L Operati expense
1	I	5 steam locals (old coaches)	$ 300 000	$ 392 1
2	I	5 Diesel loco. locals (old coaches)	$ 1 050 000	$ 243 7
3	I	5 motor train locals (old coaches)	$ 1 025 000	$ 163 0
4	II (a)	4 motor train locals (old coaches)	$ 820 000	$ 163 0
5	II (b)	4 Diesel loco. locals (old coaches)	$ 840 000	$ 207 7
6	III (a)	5 steam locals (new coaches)	$ 1 275 000	$ 392 1
7	III (a)	5 Diesel loco. locals (new coaches). . . .	$ 2 025 000	$ 243 7
8	III (a)	5 motor train locals (new coaches). . . .	$ 1 675 000	$ 163 0
9	III (b)	4 motor train locals (new coaches). . . .	$ 1 340 000	$ 163 0
10	III (c)	4 Diesel loco. locals (new coaches) . . .	$ 1 620 000	$ 207 7

(1) As compared with line 2.
(2) As compared with line 5.
(3) As compared with line 7.
(4) As compared with line 10.

TABLE 3. — **Annual dollar expense**

Lines	A Cases	B Train consists	E First costs	L Operati expense
1	IV (a)	Steam trains with 24 new double-deck cars.	$ 3 740 000	$ 602 1
2	IV (a)	Diesel loco. trains, from table I, line 6A. .	$ 6 450 000	$ 380 0
3	IV (b)	Motor trains, 25 power cars, 10 new trailers, 55 old trailers	$ 6 075 000	$ 319 2
4	IV (b)	Motor trains : 4 locals, 4 6-car expresses, 4 9-car expresses, 20 power cars and 52 old trailers	$ 4 340 000	$ 350 5
5	IV (c)	Diesel loco. trains : 4 locals, 4 6-car expresses, 4 9-car expresses, 12 locomotives, 24 old coaches, 24 double-deck cars. . .	$ 5 160 000	$ 377 4

(1) As compared with line 2.
(2) As compared with line 5.

1 for several typical cases.

M tal investment charges	N Total expense (L + M)	O Total saving over steam operation	P Total saving over Diesel locomotive operation	Q Return on investment, per cent
$ 30 000	$ 422 100	—	—	—
$ 105 000	$ 348 700	$ 73 400	—	9.8
$ 102 500	$ 265 500	$ 156 600	$ 83 200	21.6
$ 82 000	$ 245 000	$ 177 100	$ 103 700 (1) $ 46 700 (2)	34.1
$ 84 000	$ 291 700	$ 130 400	—	24.1
$ 127 500	$ 519 600	—	—	—
$ 202 500	$ 446 200	$ 73 400	—	9.8
$ 167 500	$ 330 500	$ 189 100	$ 115 700	47.3
$ 134 000	$ 297 000	$ 222 600	$ 149 200 (3) $ 72 700 (4)	343.0
$ 162 000	$ 369 700	$ 149 900	—	43.5

f table 1 for several typical cases.

M tal investment charges	N Total expense (L + M)	O Total saving over steam operation	P Total saving over Diesel locomotive operation	Q Return on investment, per cent
$ 374 000	$ 976 100	—	—	—
$ 645 000	$ 1 025 000	$ 48 900	—	none
$ 607 500	$ 926 700	$ 49 400	$ 98 300	2.1
$ 434 000	$ 784 500	$ 191 600	$ 240 500 (1) $ 108 900 (2)	32.0
$ 516 000	$ 893 400	$ 82 700	—	5.8

of four locomotive trains, so that not five, but only four motor trains would be required. Consequenly, the first costs would be reduced by the cost of one motor train, or by $ 205 000, resulting in a return on the investment spent over that needed for steam operation in the amount of 34.1 per cent (Table 2, line 4), which is quite attractive.

Case III (a)—assumes that with either steam, Diesel or motor trains, only new coaches will be used. Steam and Diesel trains remain more economical, as dividing 46 700 by 7 500 shows that six locomotives would have to be used in switching service to equal the savings by motor trains, and only four are available.

Multiple-unit trains make frequent off-hour service possible at relatively low expense.

Case II (b)—As in (*a*), it may be possible to reduce the number of trains from five to four also in case of Diesel locomotive trains, provided that the latter have a driver's cab in the last coach, and that the locomotive be allowed to push the three coaches in one direction. This case is represented by line 5 and shows a fair, yet smaller, return on the investment than the four motor trains. Even if all four locomotives could be used at night for switching purposes, line 4, column P reveals that the motor locomotive operation would then require 15, and motor-train operation only 10 new coaches, as the power cars are new coaches in themselves. Assuming $ 85 000 for each new coach, the costs will be as shown by Table 2, lines 6 to 8. While the return on the investment of Diesel locomotive trains spent in excess of that for steam trains remains as in Case I at 9.8 per cent, it increases for motor trains to 47.3 per cent.

Case III (b)—assumes as does Case II b that due to faster dispatch only four instead

of five motor or Diesel-locomotive trains will be needed. Line 9 shows that the first costs of the motor trains are almost as low as those of the steam trains, line 6, while the total annual costs are only 57 per cent of those of steam operation, resulting in a return on the investment of 343 per cent. In contrast to this, line 10 reveals that Diesel-locomotive train yield only 43.5 per cent and that, even if all four locomotives could be used at night, motor trains remain more economical.

Case IV returns to the entire system of Table I, and considers the fact that on many suburban systems 30 to 40 per cent of the existing coaches are so obsolete that replacement, rather than reconditioning, is in order.

Assuming in the hypothetical example that 35 coaches are obsolete out of a total of 90, steam operation would require the purchase of 35 single-deck coaches of $ 85 000 each or of 24 double-deck coaches of $ 110 000 each. Choosing the latter as the cheaper plan and also taking into account a reduction of fuel and car maintenance expenses of $ 10 500 due to double-deck construction, the figures of Table 3, line 1, take the place of those of Table 1, line 3A. In the case of Diesel-locomotive trains (Table 3, line 2), the figures from Table 1, line 6, are repeated because the 30 double-deck cars already take care of the replacement program. In the case of motor trains (Table 3, line 3), 25 power cars, 10 new cars and 55 old cars would be involved.

Table 3, column O, line 2, reveals that Diesel locomotive operation remains economically inferior to steam, while motor trains (line 3) yield at least a moderate saving. In analogy to Case II and with reference to Table 3, line 3, column P, 98 300/7 500, or 13 Diesel locomotives—more than are available—must find use at night to break even with motor trains.

Case IV (b) is a study of actual schedules which show that there are cases where the quicker dispatch of motor trains would permit a reduction not only of the number of locals, but also of certain expresses, as some of them can make two, instead of one trip, thereby picking up a second rush-hour load. Assuming that in the case of motor trains one local, one six-car express, and one nine-car express could be dispensed with, the costs, including the expenses of the non-revenue return trips, would be as shown by line 4 of Table 3, resulting in a 32.0 per cent return on the investment spent in excess of that necessary for steam operation.

General conclusions.

To obtain the same reduction of train numbers with Diesel locomotives the two trains making two round trips must have on the first inbound and outbound trips a second locomotive as a pusher in order to obtain a quick return. An operator's cab in the last coach would not be a satisfactory solution in this case as it might be for a three-car local because it is impractical to push more than three cars at revenue-service speeds because of flange resistance on curves. At the end of this non-revenue return the pusher locomotive takes over its regular train. The costs for this swing-locomotive operation are shown on line 5 of Table 3. To break even with motor trains, 108 900/7 500, or 14, Diesel locomotives must find full employment during off-peak hours, which is impossible as there are only 12 locomotives available.

All-out Dieselization of an entire suburban system with heavy rush-hour service cannot be justified on the ground of direct savings, excepting those cases in which at least one-third of the existing coaches must be replaced anyway for reasons of obsolescence. In these cases motor trains may become attractive, if, at the same time, because of quicker dispatch at terminals, the number of trains can be reduced. Although this can be also accomplished with Diesel locomotives, they do not measure up with motor trains, unless all or most of these locomotives can be used during off-peak hours for other purposes.

Dieselization of steam-operated locals or

shuttle trains can be economical only if these trains are kept busy during a large part of the day. In most of these cases motor trains are economically superior to Diesel locomotive trains.

If all coaches are to be replaced by new ones, or if a line with entirely new equipment is to be installed, motor trains are definitely the most economical type of equipment.

Indirect savings not included in the above analysis and obtainable by motor trains are (*a*) less congestion at terminals; (*b*) more frequent schedules, thereby soliciting more commuters; and (*c*) if later electrification should take place, the rolling stock would require only small changes.

The above conclusions must not be construed as a rigid rule. They reflect, however, a trend pattern which shows that motor trains have definite possibilities and that they may yield fair returns on the investment. Similar though slightly smaller savings, but with still greater flexibility, can be obtained if 500 to 600 HP, instead of 1 000 HP power cars are used.

[656 .211 .5 (42) & 656 .25 (42)]

Automatic train announcing apparatus.

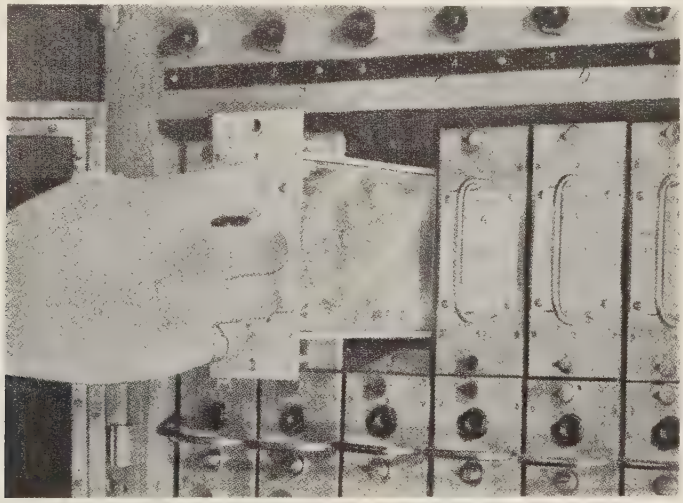
Equipment for recording and repeating a number of train announcements by using magnetic tape apparatus with quick substitution facilities.

(The Railway Gazette, August 18, 1950.)

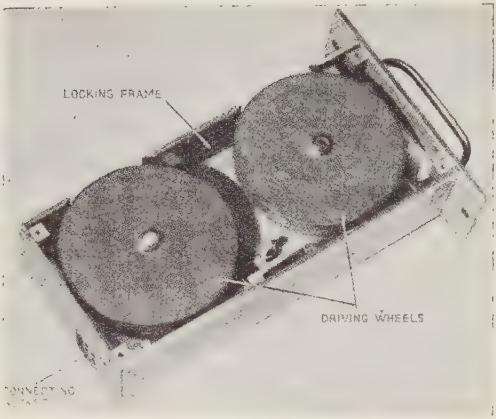
To meet the requirements of the London Transport Executive the Westinghouse Brake & Signal Co. Ltd. has developed an automatic train announcing apparatus to convey information to the public at stations. Its principles are such, however, that it can be readily adapted to a number of other purposes where such announcements need to be made. Loud speaker announcing is playing an increasing part in the directing of passengers at stations, boat landing stages, and so on, and equipment which will enable the same message to be repeated at intervals, as required, without an announcer having continually to speak it himself, or a new announcement to be arranged for easily, should prove very attractive in the transport world generally.

Use of magnetic tape.

Magnetic tape recording is used to store a number of different announcements, provision being made for each to have a maximum possible duration of 45 sec., with facility for splitting it into two parts with a break of any desired time between. These features are specifically required in the case of the L.T.E. railways, where it is neces-



Tape cassette being removed from Westinghouse automatic train announcer.



Left-hand side of cassette with the Bakelite cover removed.

sary to announce a train prior to arrival in the platform, and make a further announcement after it has arrived. The interval between them is determined by the time taken to run into the platform ; there are always at least 30 sec. between the conclusion of one announcement and the start of the next. This time is used to rewind the tape on which the first anouncement is recorded.

Value of plastic tape.

Recording on plastic tape has been used because such tape has the long playing life necessary. It has a long life mechanically and a recording made on it does not deteriorate seriously after continued re-playing ; moreover, the system has the advantage that recordings can be replayed as soon as made, immediately revealing any imperfections, while it is possible to erase an announcement at any time and re-record another on the same length of tape. The tape speed is approximately 25 cm. per sec. This gives a range of level frequency response up to about 4 Kc/s,. with the design of magnetic head employed.

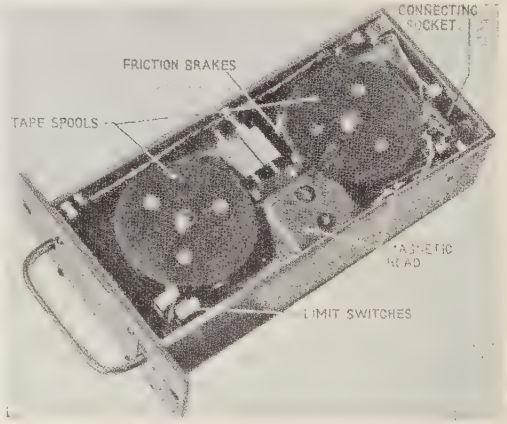
The announcements are recorded on separate lengths of tape in individually removable « cassettes », all interchangeable. The announcements can then be recorded on the tape in their cassettes at a studio remote from the announcer itself, and be sent in them to the main equipment, where no specially skilled labour is required to plug into the appropriate channels for automactic reproduction.

To change any announcements, new cassettes can be substituted in the appropriate channels, leaving the original cassettes free to be returned to the studio, for erasing and re-recording if so desired. Where different announcements are required on different days of the week, or on special occasions, spare recorded cassettes can be kept with the equipment and substituted for those already in use, as and when required.

Sealed cassettes.

The accompanying photographs show these cassettes. The tape is completely sealed against dirt and dust and automatically locked when the cassette is removed from the announcing or recording equipments, to guard against its being accidentally damaged in transit, and so on.

Each contains its own Mu-metal screened triple purpose magnetic head which can be used without adjustment for recording, re-



Right-hand side of cassette with the Perspex cover removed.

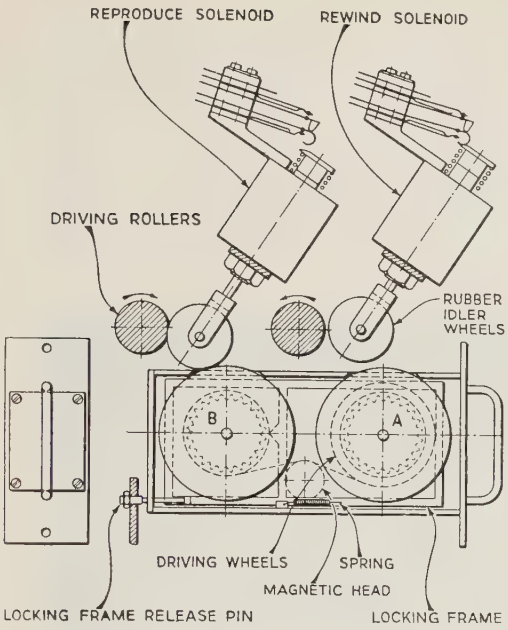


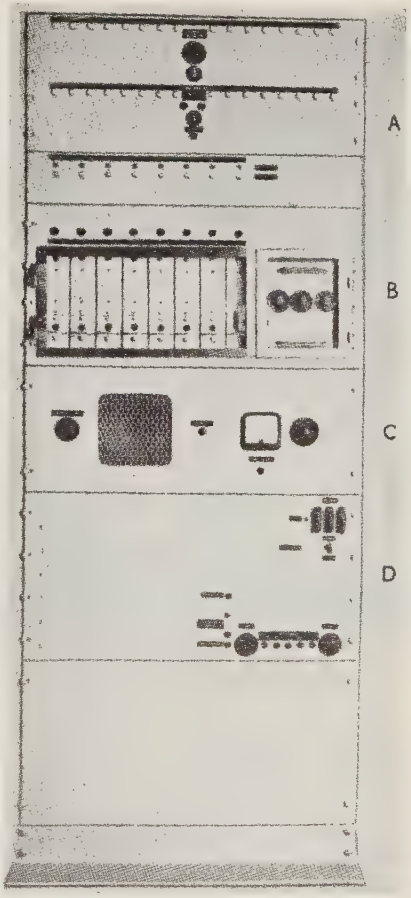
Diagram of tape cassette and driving mechanism.

producing and erasing ; moreover, once the cassette has been assembled, it is unnecessary for the magnetic head to be removed, and the problem of alignment of the magnetic gap is thereby eliminated.

The magnetic tape is wound on two spools and runs from one to the other when recording or reproducing. It is then automatically caused to rewind by limit switches incorporated in the cassettes and operating at the beginning and end of the announcement. The break in the announcement whilst the train runs into the platform is effected by stopping the motion of the tape for the required time ; the point at which this occurs is determined by a recorded low frequency pulse, amplified in a frequency selective circuit and caused to operate a relay to stop the tape. This pulse is almost inaudible in the audio output of the equipment.

The chief mechanical features of a tape cassette and driving mechanism are shown in the accompanying diagram.

The tape is wound on two « Tufnol » spools and runs from spool A to spool B during recording or reproducing, and then rewinds in the reverse direction : either direction of motion is suitable for erasing. The spools are fixed to shafts which run in double ball bearings in a brass plate, which divides the cassette into two parts, enabling



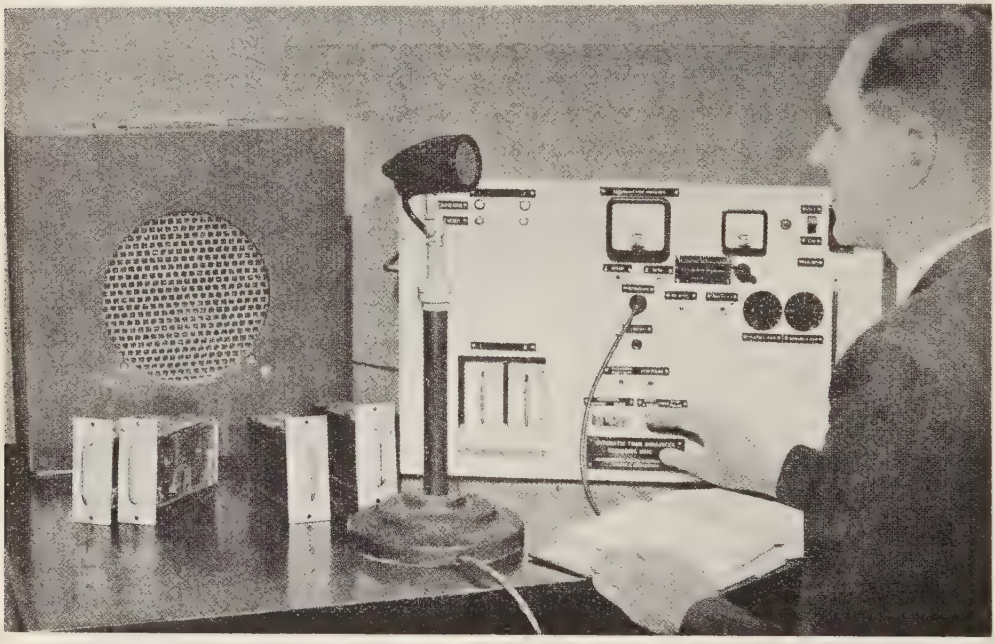
A. Relay control unit. B. Cassette driving unit.
C. Monitor unit. D. Power pack and power output amplifier unit.

Eight-channel Westinghouse automatic train announcer.

that part which contains the tape spools, etc., to be sealed against dust and dirt. The other ends of the shafts carry « Tufnol » driving wheels whose perimeter projects just beyond the top surface of the cassettes. The drive to the tape is transmitted through the rubber idler wheels by engaging them between the exposed parts of the driving wheels and either of the two rollers which run along the top of the cassettes and re-

maximum lengths of the announcements. It also enables small adjustments of these lengths to be made by setting the contacts.

Adjustable friction brakes are fitted to each tape spool, to prevent excessive overwind of the tape after the drive has been disengaged. When the cassettes are removed from the recording or reproducing equipment, the driving wheels are locked, preventing the tapes being unwound.



Westinghouse automatic train announcer recording unit in operation.

volve continuously while the motor is running. The idler wheels are moved into engagement by solenoids which also operate contacts. Only one solenoid of a pair associated can be energised at a time.

The limit switches are standard C.T.C. contacts, each arranged to close when the diameter of the roll of tape is increased to a certain critical value. This is used to operate relays, etc., to rewind the tape or disengage the drive, and so determines the

When the cassettes are plugged into the equipment, this locking becomes disengaged. Detachable bakelite covers over the driving wheels, and Perspex covers over the tape spools enable the tape to be observed without dismantling. The cassettes are normally fixed by two knurled headed screws. The announcer itself is built as a number of units, mounted on a rack and interconnected with multi-way cables. An assembly is seen in the accompanying photograph.

The equipment may be controlled through the relay control unit either automatically, by interconnection with track circuits and existing train describers, or by manual operation at the equipment itself. Control is divided into two parts, the selection of the required announcement, and initiation of the one selected ; each of the circuits which perform these functions may be switched independently to automatic or manual operation, so that apart from an all-automatic or all-manual control, it is possible to use manual selection and automatic initiation, or *vice-versa.*

As soon as an announcement has been initiated, this unit can accept and indicate the selection of the one to follow, and at the same time maintain independent control of the first, until it is completed and the tape rewound ; the new announcement is then immediately available for initiation. After an announcement, when the tape has been rewound, the synchronous motor which provides the drive, and the H.T. circuits to all the amplifiers are de-energised in order to increase the life of the equipment, leaving only the valve heaters and a low voltage D.C. circuit for relays, etc., still operating. when an announcement is initiated, the motor is started up and the H.T. brought on to the amplifiers. This condition is maintained until the announcement has been completed in both parts, and the tape rewound ; the motor and H.T. remain energised during the break in the announcement. A system of lights on the relay control unit and the cassette driving unit enables it to be seen immediately which announcement is being made or rewound, and also which is the next selected announcement.

Sockets are provided into which lines to the track circuit equipment, etc., may be plugged for automatic operation. The announcement selection circuit for automatic control consists of one common line and either 8 or 16 others, corresponding to the 8 or 16 channels in the equipment. Any particular announcement can be selected by closing a circuit between common and the line associated with the required channel. There are two lines to the automatic remote control initiation circuits, and announcements are initiated by short-circuiting them to earth. One line is used for initiating the first part of the announcement, the other for the second ; interlocking is provided to ensure that the sequence cannot be reversed.

Cassette driving unit.

The recorded tape cassettes are normally plugged into the cassette driving unit, which houses the synchronous motor, the driving rollers and the solenoids. This unit also contains the relay circuits associated with the automatic stop and rewind functions, pre-amplifiers, etc.

The amplifiers are all constructed as plug-in chassis or cassettes, to facilitate servicing. The initial amplification of the signal from the magnetic head is made in a triode stage, and there is an individual triode amplifier associated with each tape cassette, each with its input transformer and other components built into a separate plug-in cassette fitting under its tape cassette. The triode stages work into a common anode load, but are all normally biased beyond cut-off. When an announcement is being made, the bias is removed from the triode associated with the channel in operation, and thus the output from the required magnetic head only is fed into the main pre-amplifier.

The remaining amplification takes place in the main pre-amplifier, built as a plug-in chassis. The circuit comprises a three-stage pentode amplifier which feeds the signal to the power output amplifier unit, but is followed by a low frequency amplifier and output stage operating the relay used, as already described, to stop the motion of the tape when a 50 c/s. pulse is received from its output.

The monitor unit contains an 8-in. loud speaker and volume control, which can be connected by an external jack circuit to the output of the power amplifier. A meter

circuit is built into the front panel, and may be switched to record the audio output voltage of the power amplifier, or for use with further external jack circuits for checking the operating conditions at various different points.

The power output amplifier has a class « A » push-pull triode output stage, capable of delivering a peak power of 50 watts into a 200 ohm load. It is also designed with a frequency response which cuts off sharply below 500 c/s. in order to increase the intelligibility of announcements made from loudspeakers of the usual railway platform type. A microphone pre-amplifier is incorporated, with provision if necessary for remote control switching from recorded to « live » announcements.

In order to achieve the greatest possible reliability, metal rectifiers and paper condensers have been used exclusively in the construction of the power pack and all the amplifiers, with the one exception that large electrolytic condensers have been necessary in a low voltage D.C. circuit providing energisation for relays, etc., though all these condensers are operated at less than half their rated peak working voltage.

The power supply required is 200 volts 33 1/3 c/s. three-phase, but the equipment may be arranged to operate from a similar 50 c/s. supply.

Automatic recording.

In addition to the reproducing equipment already described, a recording unit has also been developed for use in the studios where the announcements would be recorded for a number of reproducing equipments.

Its main features are that the tape cassettes can be plugged directly, and without any modification, into the equipment, and an announcement can then be recorded ; the tape is automatically rewound, etc., by the operation of the limit switches, as in the announcer. When the rewind is complete, the recorded announcement can be played back, enabling any imperfections to be noticed at once. If the recording is unsatisfactory, the announcement can be erased and a new one recorded. A circuit is provided for recording 50 c/s. pulses used, as described, to divide the announcements into two parts.

These functions are controlled from two key switches ; the remaining controls need to be used only when setting up the equipment, or when there are changes in the recording conditions, and so on.

This unit is self-contained operating on 230 volts 50 c/s., single phase, with suitable motor. An electronic time indicator is energised at the beginning of each recording and indicates the time elapsed, on a standard 1 mA. meter calibrated to read 0 to 60 seconds.

The amplifier, which comprises three stages of voltage amplification with a tetrode output stage, is used both for recording and reproducing, though its frequency response characteristics are suitably corrected for each of these three functions by switching in appropriate networks in the amplifier chain.

The amplifier gain when used for recording is designed to fall off rapidly at low frequencies, as not only are these frequencies unnecessary in the announcements, and in fact also attenuated in the announcer itself, but their absence eliminates the possibility of recorded low frequency speech signals operating the automatic stop circuit other than when required.

A 40 kc/s. tetrode oscillator provides both the erasing H.F. and the H.F. recording bias, with separate pre-set controls for each.

A second meter is included on the front panel of the equipment and can be switched to measure audio recording current, high frequency « bias » current for recording, and erasing current.

[621 .431 .72 (45)]

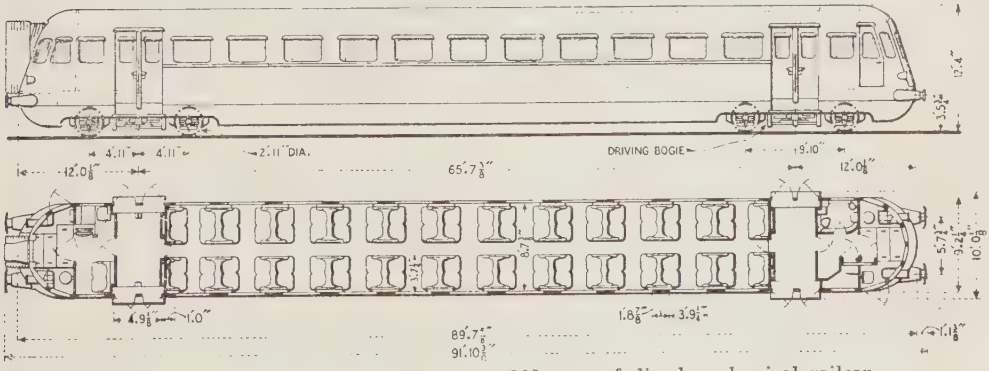
Powerful Italian railcars

A horizontal engine and full-mechanical transmission are embodied in new standard-gauge vehicles for a variety of services.

(*Diesel Railway Traction, August, 1950.*)

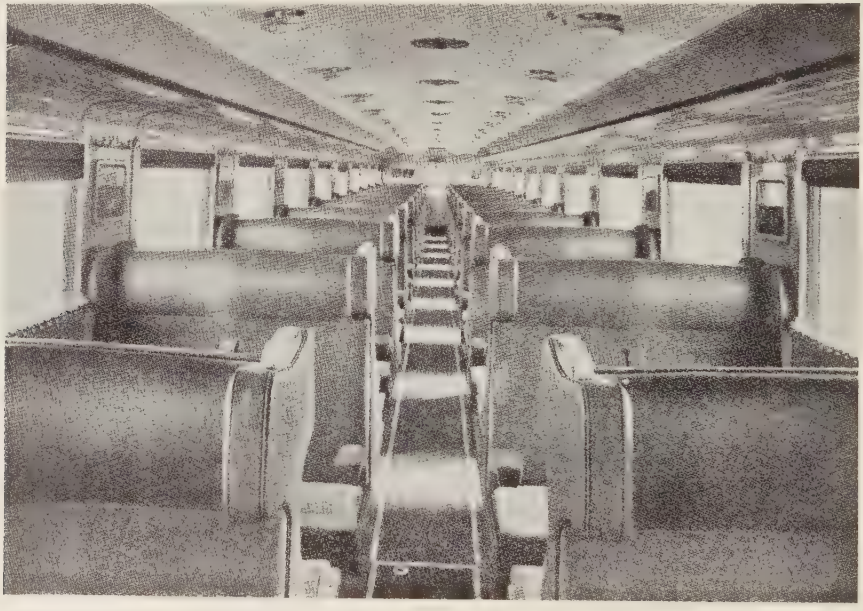
During the war something like three-quarters of the 600-odd railcars of the Italian State Railways were destroyed or badly damaged. The principles of railcar operation had been thoroughly proved before the war, and, therefore, a beginning was made in the rehabilitation of some of the damaged railcars and of placing orders for new vehicles. Experience gained in pre-war years was incorporated in the new designs and in particular the Saurer type of quick-running diesel engine was embodied in cars built at Turin by the Fiat company.

480 HP 46-ton double-bogie main-line railcar, Italian State Railways.



General arrangement of the new ALn 990 type of diesel-mechanical railcar.

Recent deliveries under this category of combined construction include a batch of railcars having exceptional technical interest in that a single engine has been installed for a top output of 480 B.HP, and that, though of the Saurer type and made by the Saurer licencee in Italy, the Officine Meccaniche, Brescia, it is of the SBD twin-bank horizontal design, a model evolved for special purposes by the Swiss company and not hitherto applied to railway work.



Interior of a one class Italian railcar in which 88 seats have been arranged in a single saloon.

This is the engine which was given brief notice on page 156 of the *Diesel Railway Traction* for September, 1949. It has 12 cylinders 6.3 in. by 7.9 in. which develop the top output stated above at a speed of 1 400 r.p.m. It is probably the most powerful high-speed horizontal engine available for railway installations, and tests have also been made at the Saurer works at Arbon with a pressure-charged model giving 750 B.HP though commercial production of this type is not yet under way.

The naturally aspirated engine was tested to a maximum of 560 B.HP at 1 400 r.p.m. at the parent works in Switzerland so that the Italian setting of 480 B.HP should prove conservative and should not lead to inordinate maintenance. Specific dry weight on the basis of 480 B.HP is about 15 lb. per B.HP; the pressure-charged version weighs about 10 lb. per B.HP against 750 B.HP, and about 11 1/2 lb. against a railway rating.

The engine is carried on the railcar frame below floor level along with the radiator and fan. The triple-disc main friction clutch is immediately behind the engine; then the drive is taken through a five-speed gear-box to the two axles of the driving bogie, which are loaded to about 30 tons with a full complement of passen-

gers and luggage. At peak engine revolutions the top gear step gives a track speed of 130 km p.h. (81 m.p.h.). The second bogie, with the same 9 ft. 10 in. wheelbase, is a carrying bogie; but both types are of the bolster type, with a combination of laminated and helical springs.

Intended operation is in solo, in multiple-unit with other cars of the same type, or in trailer hauling. To meet the last two duties a vestibule connection is fitted to one end of the car. A total of 88 passenger seats of one class is provided in one long saloon and there are two supplementary seats in « a place round the corner ». The layout is completed by a lavatory, a postal compartment, a very small luggage space, and the two driving cabs.

The passenger saloon has forced ventilation with filtered air, and the temperature is regulated by thermostat; heating is effected by an exchanger in which the incoming air is passed over ducts containing the engine circulating water. The general arrangement and principal dimensions of these railcars are shown on the diagram on page 171. Empty weight is about 45 tons and the weight with fuel and supplies is about 47 tons.

[624 .7 (44)]

Welded bridges in Northern France

Ten structures of this type have been erected by the S. N. C. F. and are giving satisfactory service under varying conditions of traffic.

(*The Railway Gazette, April 28, 1950.*)

In France, electric arc welding has been applied to railway bridges only since 1935, largely because the regulations of the Ministry of Public Works applicable to railway bridges made no provisions for arc-welded fabrication. This was remedied by new instructions issued in 1934, and revised in 1935 and 1946. As soon as they appeared, the then Chief Engineer of the Northern Railway, M. Cambournac, availed himself of the opportunity to try out this method of construction, which had already been used in other countries, and which he had already used for welding rails to bedplates.

The first arc-welded girder structure was a turntable of 78 ft. 9 in. dia. weighing 225 tons and built in 1935 at Joncherolles shed some four miles outside the Gare du Nord, Paris. Since then, the Northern Railway, and its successor, the Northern Region of the S.N.C.F., have built ten arc-welded bridges, including one with truss girders. Six are of ordinary mild steel (tensile strength 26.7 tons per sq. in.; yield point 15.2 tons per sq. in.; elongation 25 per cent.; permitted stress 8 tons per sq. in.), while the four others, including the truss bridge, are built on high-tensile steel (34-40 tons per sq. in.; yield point 23 tons per sq. in.; elongation 20 per cent.; permitted stress 12 tons per sq. in.).

Testing bridge over the Porte de Douai, Lille.

A description of these ten bridges, and an appreciation of their behaviour under traffic, has been given by M. P. Widmann, a chief officer of the Northern Region, S.N.C.F., in the Belgian periodical *L'Ossature Métallique* of February, 1950.

Underside of decking of bridge at Compiègne.

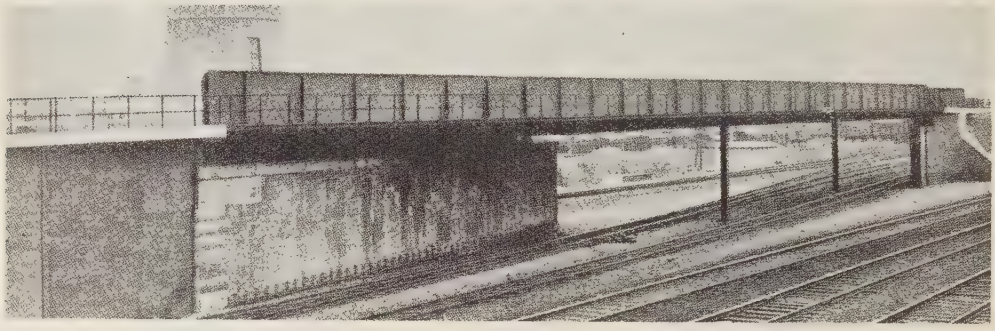
View looking along skew bridge, St. Denis.

The first of the bridges, put into service in May, 1936, is a skew bridge at St. Denis, carrying two running lines over two others and having two continuous plate-girder spans some 88 ft. and 115 ft. in length. Shortly afterwards, an important arc-welded bridge was erected to carry two main lines with heavy traffic over the widened Boulevard Ney in Paris. Of the three continuous spans of 73 ft. 2 in., 115 ft. 6 in. and 73 ft.

2 in., respectively, the central span bridges the entrance to a vehicular road tunnel. The two tracks are carried by independent superstructures each of which consists of main plate girders integrated with the intermediate pier supports; the latter are braced transversely. The total weight of this structure is 477 tons. Welding has been used throughout, except that the stringers are riveted to the cross-girders. There followed three minor bridges in the Paris area, at Le Bourget and Landy.

Truss bridge.

Before the war, the truss bridge was put into service. It is a single skew span carrying a slightly-curved single line across four suburban tracks at Joncherolles where the construction of a new engine shed for the suburban services from the Gare du Nord necessitated extensive remodelling of the lines. The length of the span is 131 ft. and it weighs 109 tons. Arc-welding was used exclusively in its fabrication, and it has concrete decking.



Skew plate-girder bridge at St. Denis.

Truss bridge over suburban lines at Joncherolles, near Paris.

The construction of this bridge had been the subject of extensive research, carried out by the contractors (Schmid, Bruneton et Morin) in collaboration with M. Cambournac of the S.N.C.F. and his staff. The objects of the research were to reduce the secondary stresses due to the rigidity of the structure and to the contraction due to the welding, and to avoid, for this reason, the concentration of welding at the gussets. Further aims were to reduce the thickness of the sections to be welded, leave the welding joints in an easily accessible position and minimise the amount of welding to be done at site.

As a result of this research, the bridge has unorthodox features. The I-beam forming the upper chord is placed horizontally to facilitate the assembly of the diagonals and obtain a higher resistance to secondary stresses. The bottom chord, on the other hand, consists of a flat plate about 1 1/2 in. thick which adapts itself readily to deformation. Vertical members have been omitted so as to reduce the number of welding joints at the gussets. In the calculations all known secondary stresses were taken into consideration. When the main girders were assembled in the workshop, they were subjected to stresses similar to those encountered in service, by means of hydraulic jacks acting on the horizontally-placed girder. The girders were then positioned by means of a 32-ton crane.

Another four welded bridges have been built since the war at Stors, Compiègne, Abbeville, and Lille. That at Lille, situated on the main Lille-Béthune line, is by far the most important. The bridge for the down line, carrying 119 heavy trains and five railcars a day, has been in operation since August, 1949. The corresponding bridge for the up line is in course of completion. These twin 85-ft. skew spans, weighing 123 tons, are over an important road in the vicinity of the new station at Lille South, replacing three level crossings.

Three-span bridge carrying main line over Boulevard Ney, Paris.

Concluding his survey, the author confirms that all the ten bridges have proved entirely satisfactory in service. The bridge at St. Denis was hit by a bomb, but due to the homogeneity of the welding, the damage was superficial and could be repaired by arc-welding at site. The truss bridge at Joncherolles successfully withstood repeated tests.

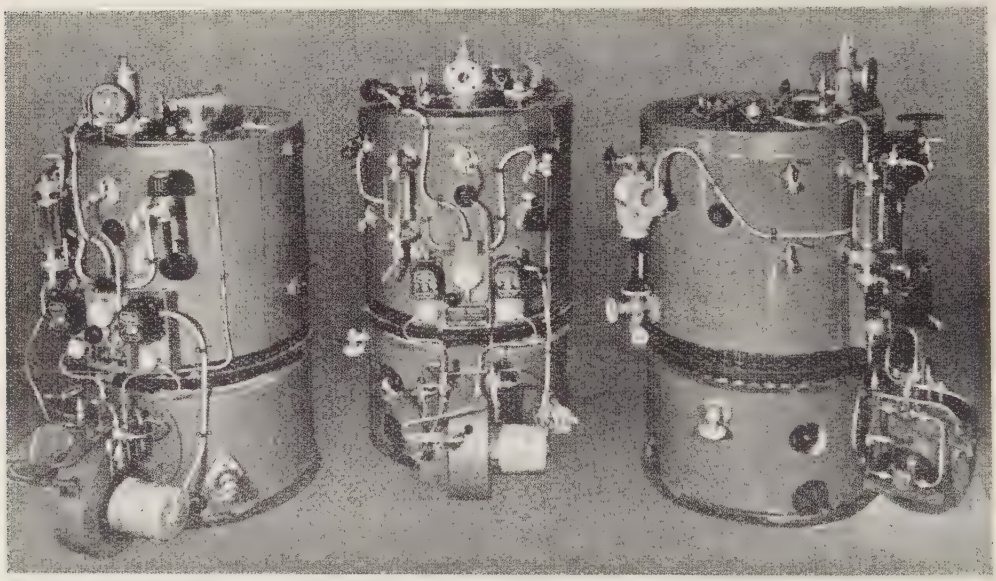
[625 .234]

Boilers for train heating.

(From the Diesel Railway Traction, September, 1950.)

During recent years the rapid development of diesel railway traction has made it necessary to pay particular attention to the provision of alternative heating arrangements to take the place of supplies of steam previously available from the steam locomotive.

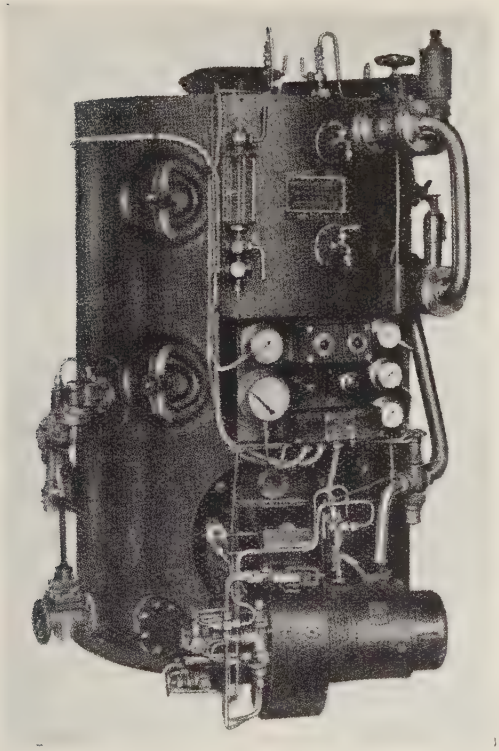
The photograph reproduced below shows three Spiralflo boilers delivered for service on British Railways. Ordered for a steam delivery of 600 lbs. per hour at 50 p.s.i.g., these boilers on test gave an output of 800 lbs. per hour. Their height is 5 ft., and the diameter over lagging 3 ft. 1 in.



Three Spiralflo boilers, ordered for a steam delivery of 600 lbs. per hour at 50 p.s.i.g., which gave an output of 800 lbs. per hour on test.

Basing their ideas on warship experience over a number of years, the firm of Spanner Boilers Limited, 10, Hopton Road, London, S.W.16, has produced a series of oil-fired waste-heat boilers of extremely small size and weight in relation to the amount of steam produced. Most of these are equipped with helically-grooved Swirlyflo fire-tubes.

The illustration on the top of next page shows another Spanner boiler — a Swirlyflo — also built for British Railways and guaranteed to produce 1 500 lbs. of steam per hour at a working pressure of 80 p.s.i.g. On trials this boiler delivered steam at the rate of 1 650 lbs. per hour. The height of the boiler is 5 ft. 6 in. and the diameter over lagging only 3 ft. 8 in. Similar boilers



Spanner boiler of the Swirlyflo type built to produce 1 500 lbs. of steam per hour.

having a duty of 400 lbs. of steam per hour at 60 lbs. p.s.i.g. have been supplied to Coras Iompair Eireann.

For each of these different boilers, the burner fitted is a Laidlaw-Drew pressure jet unit of the Snail type, specially designed by Spanner Boilers Limited to suit railway and marine needs for very compact and highly effective burner units.

The firm has worked on the idea that, in the case of diesel trains, coach heating arrangements should properly be met by making use of the heat in the exhaust gases in the case of trains having high-powered locomotives and a large number of carriages, and by making use of the heat in the engine cooling water *plus* the heat in the exhaust gases in the case of diesel railcars and short (two or three unit) trains in which water heating can be used.

Essential requirements.

To make it possible for heat from the exhaust gases to provide the steam required, it is essential :

(*a*) That the waste-heat unit should be designed so that steam is raised immediately the train starts.

(*b*) That the waste-gas unit should take the maximum possible amount of heat from the exhaust gases.

(*c*) That the waste-heat unit should be very easily cleaned on the exhaust-gas side.

(*d*) That the waste-heat unit should function as a silencer and with no more back pressure than would be imposed by a silencer.

(*e*) That the waste-heat unit should be all-welded and capable of being run dry when heat is not required during summer periods.

The photograph reproduced below shows three units ordered as a result of successful experiments under service condi-

Three Spanner waste-heat boilers for raising 350 lbs. of steam per hour.

tions. Each unit raises 350 lbs. of steam per hour at 30 p.s.i.g. from cold feed when passing the exhaust from two 130-B.H.P. engines. One of the units in the illustration is standing vertically in the centre, and the top and bottom views of these units are shown on the left and right-hand sides.

The gas discharges from the two engines enter the boiler at the bottom through the bent pipes, passing up and down through the boiler and coming out through two discharge pipes facing towards the front of the photograph of the boiler shown vertically. Quick-release covers, held by two bolts, are provided at the bottom and top of each boiler. These ensure that it is an easy matter to sweep the tubes without disturbing the boiler connections in any way.

In the first boiler built, the top cover was secured by butterfly nuts, and the bottom cover by bolts, but cleaning has been made much simpler by the development of the quick-release covers adopted for the repeat boilers. These boilers are 6 ft. high tube plates and 2 ft. 4 in. in dia. over lagging.

A Swirlyflo booster unit 2 ft. 6 in. long over tube plates and 12 in. in dia. over lagging is supplied for diesel railcars to raise the temperature of the engine-cooling water by 15° F. to 20° F. before this is passed into the railcar heating system. It is found in practice that by boosting the temperature of the engine-cooling water in this way, a much more satisfactory heating result is secured than when reliance is placed on the heat in the cooling water only.

Automatic heat adjustment.

Simple systems have also been developed by which the output of steam, or the delivery of hot water, is automatically adjusted to meet the requirements of passengers while the train is in service.

In the case of the oil-fired boilers the adjustment is generally by way of automatic control of the oil burner consumption, and in the case of steam raising by the use of waste heat the control is generally by variation of the rate of feed water supply, while in the case of water heating the control is generally by way of automatic by-passing of the flow of cooling water from the engine.

NEW BOOKS AND PUBLICATIONS.

[656 .2]

Transports. — The operation of a railway. Summary of its organisation. *Volume I : Technical operation; Volume II : Commercial operation. General business.* — Geneva 1931/32. Published by the International Institute for the Scientific organisation of work. — Two volumes (7 7/8 · 11 3/4 in.), a total of 408 pages with illustrations.

If the International Institute for the Scientific Organisation of Work had wished to explore a domain in which organisation flourished, it would be hard to find a better choice. The railway offers an abundance of examples of the application of the spirit of analysis and inventive genius.

Undoubtedly in some cases, it is question of arrangements based on unavoidable needs simply to assure the working of the services, but in many other cases, we can see the results of patient and methodical investigations inspired by a desire to improve the quality of the transport offered to the public and the need to increase the output of the undertaking. Whether it is legitimate to apply the phrase scientific organisation to any of these arrangements is for the specialists to decide. However, the constant evolution in which the railway shares must be taken as a proof we are always trying to profit by new ideas and the progress achieved by science and technical knowledge.

As the publishers have stated, this publication is not intended to give a complete report of the inside working of a railway. But working in the atmosphere of the Institute which they represent, they have endeavoured to collect together such details as will enlighten the reader concerning certain aspects of railway operation, and show him the happy results obtained by a spirit of organisation.

These details prepared by well informed technical experts cover a great many aspects, explain the problem to be solved, the solutions made use of, and above all stress the considerable efforts involved.

The International Institute for the Scientific Organisation of Work has grouped these studies and arranged them according to a rational plan. The plan adopted was inspired in the first place by a consideration of the various peripheries through which the wagon or coach moves according to the lines on which they run and the stations which have to consign or receive them. Then recalling the final object of all these movements, the authors have developed the programme by describing the prospective market, the possibilities of competition, the settling of the rates, advertising, the keeping of accounts. The financial aspect is also linked up with the output of the staff, statistics, and the determination of costs.

The reader, who studies the information given in this collection, will see that there are no operation questions which have not been systematically studied, at least to some extent. And yet, however extensive, the documentation is far from having exhausted the matter. The authors look upon it as an anthology to stimulate the curiosity of their readers and serve them as a guide. With this object, each chapter is followed by a bibliography, necessarily incomplete but paving the way for future research.

Not all the studies published in this collection are new; some of them have already appeared in the *Railway Congress Bulletin*. These were distinguished by their special and lasting interest which justified their inclusion in the book, side by side with new studies.

These two volumes constitute an important work, both as regards the matter dealt with and the illustrations given of the great possibilities of organisation. They may well prove a revelation to some, as apart from readers of technical literature, such applications in the railway field are far too little known and should be more widely publicised.

E. M.

[**621** .3 (06]

Transactions of the Second International Congress on Electroheat and Electrochemistry. — The Hague, 3-4 September 1947. — One volume (6 1/2 × 9 3/4 in.) of 504 pages, illustrated. — Arnhem. Published by the N. I. V. E. E. (Nederlands Instituut voor Electrowarmte en Electrochemie).

This volume contains a complete report of the work of the Hague Congress.

After the list of delegates, who were very numerous and represented some dozen European countries, it gives the text of the speeches made during the ceremonies which preceded and followed the meetings of the different sections. The main questions dealt with were mentioned and their importance stressed from the technical and economic points of view. But the main interest lies in the discussions provoked by the reports presented.

As we stated in the *Bulletin* for November 1948 these reports, numbering 29, were divided into six groups each covering a given subject. In each group a special report summed up the question, with the personal opinions or additional contribution of the special reporter.

The transactions reproduce the complete text of the original reports and the special reports, and follows them by reporting the discussions to which they gave rise.

Very frequently the remarks made and questions asked by the special reporter led to very instructive exchanges of opinion.

Especially was this the case in Section B where very valuable precisions were made concerning the question of heating buildings.

In Group C (industrial resistance furnaces) a prolonged discussion dealt with the various arrangements of furnaces and the quality of materials used both in their construction and for the resistances.

Various points were raised concerning high frequency induction furnaces (Group D). A new communication added to the information concerning electronic tube furnaces.

The recording and regulating of the temperature was the subject of two Swiss reports, in addition to the special report. To the additional information supplied on the subject of regulation by thermostats, one of the reporters added details concerning a new heat regulating apparatus called the « Telinduct ».

In section F (Electrolysers) the single reporter who covered this question and described the bipolar Oerlikon electrolyser at the end of the special report gave some general remarks concerning the cost of current according to the power of the installations and on the respective qualities of the different categories of electrolysers.

Owing to the ever increasing extent of electrical applications, the engineer is obliged to select his subject and devote himself specially to a given part of this vast field. Amongst the questions dealt with at the Hague Congress some will prove of particular interest to certain readers. The necessarily brief details which we have given may serve as a guide and will encourage them to read for themselves the part of the transactions which concerns their own special field.

Even if we limit ourselves to electric heating, we find ourselves faced with such an abundant documentation that it has seemed necessary to go very far in investigating the subdivision 621.36 of the decimal classification. One of the group A reporters dealt with this question and showed how it has now become necessary to revise the classification of international documentation adopted in 1936. It was agreed that suggestions be collected by the N.I.V.E.E. at Arnhem which has already begun the work of revision.

E. M.

MONTHLY BIBLIOGRAPHY OF RAILWAYS[1]

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(MARCH 1951)

016. 385. (02]

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Tome II : un volume (19 × 28 cm) de XVI + 696
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[016. 385. (05]

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FAUCONNIER (M.). — L'**apprentissage** aux Chemins de fer belges. (2 000 mots & fig.)

1950 **656** .212 .5 (44)
Notre Métier, 5 juin, p. 6.
Le **triage** de Toulouse-St-Jory. (2 000 mots & fig.)

1950 **625** .28 (485)
Notre Métier, 12 juin, p. 4.
STEAD (A. L.). — Le **problème des locomotives** en Suède. (1 200 mots & fig.)

1950 **621** .33 (493)
Notre Métier, 19 juin, p. 8; 26 juin, p. 10.
L'**électrification** en Belgique. (4 000 mots & fig.)

1950 **621** .335 (44)
Notre Métier, numéro spécial (n° 261), p. 8.
La **première automotrice fonctionnant sur courant monophasé 20 000 volts, 50 périodes.** (1 000 mots & fig.)

1950 **625** .173 (44)
Notre Métier, numéro spécial (n° 261), p. 9.
FORCE (G.). — **Renouvellement des voies** sur la Région du Nord, à une allure record. (2 500 mots & fig.)

1950 **625** .42 (44)
Notre Métier, 3 juillet, p. 6.
VAUQUESAL-PAPIN. — **Cinquante ans de Métro.** (2 000 mots & fig.)

1950 **625** .231 (44)
Notre Métier, 3 juillet, p. 8.
VILAIN (L.). — **Modernisation des voitures à essieux** de la Région du Sud-Ouest. (1 200 mots & fig.)

1950 **625** .42 (44)
Notre Métier, 10 juillet p. 6; 17 juillet, p. 8.
BÈGUE (A.). — **Cinquante ans de Métro.** (5 000 mots & fig.)

1950 **621** .335 (492)
Notre Métier, 24 juillet, p. 2.
Locomotives électriques B-B construites en France pour les Chemins de fer Néerlandais. (1 600 mots & fig.)

1950 **656** .1 (481)
Notre Métier, 24 juillet, p. 5.
HELLAND-HANSEN (K.). — La Norvège et son **trafic routier.** (1 000 mots & fig.)

1950 **624** .51 (44)
Notre Métier, 24 juillet, p. 6.
Le **pont suspendu** de Saint-Germain au Mont-d'Or. (1 600 mots & fig.)

Rail et Route. (Paris.)

1950 **621** .335 (44)
Rail et Route, janvier, p. 6.
Présentation de la **nouvelle locomotive électrique CC 7001.** (2 500 mots & fig.)

1950 **621** .431 .72 (44)
Rail et Route, janvier, p. 10.
BARRY (M.). — Les **remorques d'autorails.** (2 500 mots & fig.)

1950 **621** .33 (44)
Rail et Route, février, p. 1; mars, p. 1.
BRASSEUR (P.). — L'**électrification** de la ligne Paris-Lyon. (5 000 mots & fig.).

1950 **625** .6 (675)
Rail et Route, février, p. 14; mars, p. 11.
Le **réseau des Chemins de fer vicinaux du Congo.** (7 000 mots, tableaux & fig.)

1950 **621** .431 .72 & **625** .13
Rail et Route, avril, p. 1.
DEVAUX (P.). — La **locomotive « Diesel-électrique »** fera-t-elle disparaître les locomotives à vapeur? (5 000 mots & fig.)

1950 **656** .213
Rail et Route, avril, p. 9.
LATOUR (M.). — Les **embranchements particuliers.** (5 000 mots & fig.)

1950 **656** .257
Rail et Route, mai, p. 2.
DEVAUX (P.). — Le **Rail automatique.** (1 500 mots & fig.)

1950 **625** .232 (4)
Rail et Route, mai, p. 9.
Les **nouvelles voitures métalliques** de la Compagnie Internationale des Wagons-Lits et des Grands Express européens construites en 1948 et 1949. (1 000 mots & fig.)

Revue de l'Aluminium. (Paris.)

1949 **669**
Revue de l'Aluminium, novembre, p. 361.
LAVAL (G.) & SCHWEYCKAERT (R.). — **L'usinage des alliages légers.** (5 000 mots & fig.)

1949 **625** .245 (44) & **669** .71 (44)
Revue de l'Aluminium, décembre, p. 425.
REINHOLD (J.). — Le **wagon S. T. E. M. I. à grande capacité et à déchargement automatique.** (2 000 mots & fig.)

1949 **656** .211 .5 (45) & **669** .71 (45)
Revue de l'Aluminium, décembre, p. 430.
La **nouvelle toiture de la gare de Milan a été refaite en aluminium.** (500 mots & fig.)

1950 **656** .225 (44) & **656** .261 (44)
Revue de l'Aluminium, avril, p. 142.
Un **container pliant** pour la S. N. C. F. (250 mots & fig.)

1950 **621** .13 & **621** .335
Revue de l'Aluminium, mai, p. 192.
Modèles de printemps pour les **locomotives.** (2 500 mots & fig.)

1950 **621** .392 & **669** .71
Revue de l'Aluminium, juin, p. 237.
GUINARD (Ch.). — Le **soudage à l'arc des métaux légers** avec électrode fusible enrobée. (3 000 mots & fig.)

1950 **625** .245 (71) & **669** .71 (71)
Revue de l'Aluminium, juillet-août, p. 277.
Un **wagon canadien à blé est allégé** de 5,5 tonnes. (600 mots & fig.)

Revue Générale des Chemins de fer. (Paris.)

1950 **388** (44)
Revue générale des Chemins de fer, février, p. 47.
COURSON. — Les **transports en commun de voyageurs** de la Région Parisienne. (3 500 mots & fig.)

1950 **385** .11
Revue générale des Chemins de fer, février, p. 53.
HUTTER. — Qu'est-ce que le **coût marginal?** (6 000 mots & fig.)

1950 **656** .257 (44)
Revue générale des Chemins de fer, février, p. 64.
GAILLARD (P.). — Le poste I « Tout Relais » de la gare de Perrigny. (3 000 mots & fig.)

1950 **621** .132 .3 (44)
Revue générale des Chemins de fer, février, p. 72.
DE CASO. — La **locomotive 232-U-I.** (3 700 mots, planches & fig.)

1950 **625** .232 (4)
Revue générale des Chemins de fer, février, p. 79.
Les **nouvelles voitures métalliques** de la Compagnie Internationale des Wagons-Lits et des Grands Express européens. (1 000 mots & fig.)

1950 **656** .257 (44)
Revue générale des Chemins de fer, avril, p. 143.
WALTER. — Le nouveau **poste électrique à itinéraires enregistrés** de la S. N. C. F. (1 500 mots.)

1950 **656** .257 (44)
Revue générale des Chemins de fer, avril, p. 146.
DUBOUDIN & VIROL. — Le **poste** de la gare de Montereau. (8 000 mots & fig.)

1950 **656** .222 (44)
Revue générale des Chemins de fer, avril, p. 161.
BOHL (G.). — **Appareil de la S. N. C. F. pour le tracé des horaires des trains.** (3 000 mots & fig.)

1950 **621** .33 (437)
Revue générale des Chemins de fer, avril, p. 175.
L'**électrification du noeud ferroviaire** de Varsovie. (3 500 mots et carte.)

In German.

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1950 **656** (44)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Nr 1, S. 1.
DAUTRY (R.). — Le nouveau décret français de **coordination des transports ferroviaires et routiers.** (16 000 mots.)

1950 **385** .15
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GRIMM (R.). — **Verstaatlichung der Privatbahnen.** (10 000 Wörter.)

1950 **656** .1
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Nr 1, S. 54.
MEYER (Dr. H. R.). — Die kostengerechte **Fiskalbelastung der Motorfahrzeugverkehrs.** Ein aktuelles verkehrswirtschaftliches Problem. (12 000 Wörter & Tafeln.)

1950 **656** (42)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Nr 2, S. 113.
SHERRINGTON (C. E. R.). — **Economics of the British Transport Scene** 1948-1949. (12 000 Wörter & Tabellen.)

1950 **385** .15 (494)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Nr 2, S. 141.
FISCHER (W.). — Die **Verstaatlichung weiterer Privatbahnen** der Schweiz im Lichte der Tarifpolitik. (8 000 Wörter.)

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1950 **621** .133 .1
Zeitschrift des Vereines Deutsch. Eisenbahningenieure, Heft 7, November, S. 56.
HINTERWÄLDER (K.). — Ein Beitrag zur **Kohlenersparnis im Lokomotivdienst.** (500 Wörter & Abb.)

1950 **625** .151 (43)
Zeitschrift des Vereines Deutsch. Eisenbahningenieure, Heft 7, S. 58.
MÜLLER (A.). — **Weichenabsteckung mit Hilfe des Winkelbildverfahrens.** (1 500 Wörter & Abb.)

1950 **625** .236
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GENSCH. — Die **Reinigung der Reisezugwagen.** (1 000 Wörter.)

1951 **691** (43)
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KÜHRT. — Das Wichtigste über den **Holzschutz.** (4 000 Wörter.)

In English.

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1949 **62** (01
Engineering, No. 4370, October 28, p. 437.
LAZLO (F.). — **Local overstraining of metals** *(to be continued).* (5 000 words & fig.)

1949 **621** .331 (42)
Engineering, No. 4370, October 28, p. 446.
Supervisory control at London Central Line substations. (2 000 words & fig.)

1949 **625** .14 (42)
Engineering, No. 4371, November 4, p. 473.
Stabilisation of soft track formation by sand piling. (600 words & fig.)

1949 **621** .132 .1 (68)
Engineering, No. 4371, November 4, p. 475.
2-ft. gauge locomotive for South Africa. (400 words & fig.)

1949 **669**
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PEARSON (H.). — **Developments in gear production.** (4 000 words & fig.)

1949 **625** .14 (42)
Engineering, No. 4372, November 11, p. 498.
ROBERTSON (V. A. M.). — **Civil engineering on the British Railways.** (4 400 words & fig.)

1949 **621** .33 (42)
Engineering, No. 4372, November 11, p. 510.
Double-deck suburban electric-train; British Railways. (600 words & fig.)

1949 **621** .13 (42)
Engineering, No. 4373, November 18, p. 521.
Limits and fits for locomotive work; London Midland Region. (5 200 words, tables & fig.)

1949 **621** .335 (81)
Engineering, No. 4373, November 18, p. 529.
3000 HP, 3000 Volt direct-current locomotives for Brazil. (1 200 words.)

1949 **621** .94
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Dust-collecting grinding machine. (400 words & fig.)

1949 **385** (071 .3 (42) & **625** .4 (42)
Engineering, No. 4375, December 2, p. 587.
Instructional train for London Transport Railway staff. (1 300 words & fig.)

1949 **621** .33 (42)
Engineering, No. 4376, December 9, p. 614.
Modernisation of the Liverpool Southport electric railway. (1 800 words & fig.)

1949 **669**
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PORTEVIN (A.) & DANNENMÜLLER (M.). — **Segregation and liquation of alloys.** (3 200 words & fig.)

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1950 **621** .438 (73)
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Modern Transport, March 25, p. 8.
WARDER (S. B.). — **Traction substations on British Railways.** (2 600 words & fig.)

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Modern Transport, March 25, p. 16.
COX (E. S.). — **Electric locomotives.** (1 200 words & tables.)

1950 **621** .4 (42)
Modern Transport, April 1, p. 10.
PICK (T. S.) & DELL (R.). — **Underground railway practice.** (800 words.)

1950 **621** .33 (42)
Modern Transport, April 1, p. 11.
CONSTANT (M. E.) & CRAIG (C. A.). — **Conductor rails and shoe-gear.** (1 500 words & fig.)

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Modern Transport, April 1, p. 15.
SYKES (W. J. A.). — **Electric locomotives.** (1 500 words & fig.)

1950 **621** .338 (42)
Modern Transport, April 1, p. 16.
BARTON (H. H. C.). — **Maintenance of electric rolling stock.** (1 200 words & fig.)

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Mc KENNA (D.). — **Electric rolling stock.** (1 800 words.)

1950 **621** .335 (42) & **621** .338 (42)
Modern Transport, April 1, p. 18.
SINCLAIR (F. W.). — **Lightweight motor and trailer coaches.** (2 000 words & fig.)

1950 **621** .431 .72 (5)
Modern Transport, April1, p. 19.
WOODHOUSE (L. C.). — **Diesel-electric trains.** (1 600 words & fig.)

1950 **621** .33 (42)
Modern Transport, April 8, p. 17.
COCK (C. M.). — **Economics of railway electrification.** (1 800 words & fig.)

1950 **621** .335 (42)
Modern Transport, April 8, p. 20.
Electric traction. (1 300 words & fig.)

1950 **621** .138 .5 (42) & **621** .392 (42)
Modern Transport, April 22, p. 15.
Welding of locomotive plate frames. (1 300 words & fig.)

1950 **625** .24 (42)
Modern Transport, April 29, p. 13.
GAMMON (C. A.). — **Standardisation of wagon design.** (2 000 words & fig.)

Proceedings.
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1950 **624** .7
Proceedings-American Society of Civil Engineers, April, Vol. 76, Separate No. 13.
BARRON (M.). — **Reinforced concrete skewed rigid frame and arch bridges.** (7 700 words & fig.)

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1950 **624** .2
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Cooper's bridge loadings. (6 00 words & fig.)

1950 **621** .35 (42) & **656** .25 (42)
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Batteries for track circuit and signal and point operation. (1 200 words & fig.)

1950 **625** .25 (6)
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Rolling stock for Nigerian Railway. (850 words & fig.)

1950 **625** .13 (725)
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Assembly-line methods in sea pier construction. (1 100 words & fig.)

1950 **656** .212 .5
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WARWICKER (H. W.). — **Gradients in hump marshalling yards.** (1 200 words.)

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WALSH (R. E.). — **Flame clearing structural steelwork.** (1 800 words.)

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Belgian Railways first electric locomotive. (800 words & fig.)

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Electrification from Laroche to Dijon inaugurated. (2 000 words & fig.)

1950 **625** .23
Railway Gazette, February 3, p. 137.
Window glazing for coaching stock. (600 words & fig.)

1950 **624** .32
Railway Gazette, February 10, p. 160.
The New Chiromo bridge, Nyasaland. (1 000 words & fig.)

1950 **625** .144 .4
Railway Gazette, February 10, p. 165.
A light weight hydraulic jack. (280 words & fig.)

1950 **621** .138 .5 (42)
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Repair of locomotive plate frames. (2 800 words & fig.)

1950 **656** .234 (42)
Railway Gazette, February 24, p. 215.
LAUNDY (J. H.). — **Railway passenger fares.** (1 900 words.)

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BOWLER (J. E.). — **Wheel slip indicators and relays** (1 300 words & fig.)

1950 **625** .26 (42)
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Wagon shops at Ashford works, Southern Region 1/2/3. (2 500 words & fig.)

1950 **313** .385 (42)
Railway Gazette, February 24, p. 230.
British Transport Commission statistics. (300 words & tables.)

1950 **621** .135 .2
Railway Gazette, March 3, p. 247.
Mechanics of wheel and rail. (1 100 words & fig.)

1950 **624** .7 (493)
Railway Gazette, March 3, p. 252.
Bridge reconstruction in Eastern Belgium. (1 300 words & fig.)

1950 **656** .25 (42)
Railway Gazette, March 10, p. 275.
MOTT (J. E.). — **Links between track and train in A. T. C.** (2 200 words & fig.)

1950 **621** .33 (42)
Railway Gazette, March 24, p. 331.
Railway electrification in Great Britain. (1 200 words.)

1950 **621** .33 (42)
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Electrification of the Liverpool street-Shenfield lines. (1 300 words.)

1950 **621** .33 (42) & **625** .4 (42)
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Traction substations. (1 800 words & fig.)

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HOWARD (A.) & BUCKLAND (B. O.). — **Gas-turbine performance.** (2 500 words & fig.)

1949 **621** .138 .1 (73)
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Modern engine terminals for steam power. (2 000 words & fig.)

1949 **625** .285 (73)
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Milwaukee 1000-HP rail cars. (1 000 words & fig.)

1949 **625** .25 (73)
Railway Mechanical Engineer, February, p. 66.
Electro-pneumatic brake devices. (1 000 words & fig.)

1949 **625** .242 (73) & **625** .26 (73)
Railway Mechanical Engineer, February, p.79.
C. & E. hopper-car program. (2 000 words & fig.)

1949 **621** .338 (73)
Railway Mechanical Engineer, February, p. 89.
FRANK (E. G.). — **Reading adds car to M. U. fleet.** (2 000 words & fig.)

1949 **625** .25 (73)
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STEWART (C. D.). — **The A. B. load compensating brake.** (3 600 words & fig.)

1949 **621** .431 .72 (73)
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BALDWIN (M. J.). — Twenty-five years progress in **traction motor design.** (2 600 words & fig.)

In Spanish.

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1950 **656** .223 .2
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BULTO (V.). — **Velocidad del ciclo de los vagones.** (2 500 palabras.)

1950 **621** .33 (44)
Ferrocarriles y Tranvias, febrero, p. 64.
Nuevas perspectivas de la electrificación en Francia. (1 500 palabras & fig.)

1950 **625** .245 (460)
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NAVARRO GIL (L.). — **Transportes pesados.** (2 000 palabras & fig.)

In Italian.

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L'Ingegnere, novembre, p. 1193; dicembre, p. 1319.
GRIOLI (G.). — **Equilibrio elastico dei ponti.** (7 500 parole & fig.)

1949 **656** (45)
L'Ingegnere, novembre, p. 1201.
ARIANO (R.). — Il « **coordinamento dei trasporti** » al III Congresso Italiano dei Trasporti. (4 000 parole.)

1950 **62** (01
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PETROZZI (E.). — Alcune notizie sul **tensiometro a variazione di resistenza.** (7 000 parole & fig.)

1950 **656** .2
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ANGELINI (J.). — **Pregi e virtú dell' « Unità bloccata ».** (3 000 parole & fig.)

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D'ARMINI (P.). — Disciplina dell' autotrasporto e **coordinamento strada-rotaia.** (5 000 parole.)

1949 **621** .431 .72
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DE ROSSI (M.). — **Trazione Diesel-elettrica con batterie tampone.** (4 000 parole, tabelle & fig.)

1949 **656** (44)
Trasporti Pubblici, novembre-dicembre, p. 1057.
STAGNI (E.). — **Coordinamento e armonizzazione dei trasporti** ferroviari e stradali in Francia. (20 000 parole.)

1949 **385** .57 (45)
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BOGANELLI (Dr. E) & DRAGOTI (Dr. G.). — **Il controllo psicotecnico dei conducenti di autoveicoli per trasporti pubblico collettivi.** (5 000 parole & fig.)

1950 **656** .1 (45)
Trasporti Pubblici, gennaio, p. 5.
VEZZANI (F.). — **Entità e costo degli autotrasporti** nell' anno 1949. (5 000 parole & tavole.)

1950 **62** (01 & **624** .8
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GRECO (G.). — L'esploratore elettromagnetico ideato dal dott. Müller. (2 000 parole & fig.)

1950 **656** .25
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CURTI (C.). — **Circuiti di binario a corrente codificata.** (2 000 parole & fig.)

In Netherlands.

Spoor- en Tramwegen. (Utrecht.)

1950 **621** .33 (492)
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V. D. HOEK (E.). — De **electrificatie** in Noord-Brabant. (1 500 woorden & fig.)

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JORDENS (E.). — **Electrificatie** Noord-Brabant. (1 500 woorden & fig.)

1950 **621** .335 (492)
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KOSTER (J. P.). — **Trekkracht- en aanzetkarakteristieken** van de nieuwe BoBo locomotieven der N. S. (3 000 woorden & fig.)

1950 **656** .212 .5 (492)
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LAMMERTINK (E.). — **Gelijktijdige treinsamenstelling** (formation simultanée) te Onnen. (2 200 woorden & fig.)

1950 **621** .33 (493)
Spoor- en Tramwegen, nr 11, 1 Juni, p. 169.
MUSYCK (J.). — De **electrificatie** van de Belgische spoorwegen. Plechtige openstelling van de electrische lijn Brussel-Charleroi. (3 000 woorden & fig.)

1950 **625** .14 (492)
Spoor- en Tramwegen, nr 10, 18 Mei, p. 164; nr 11, 1 Juni, p. 179; nr 13, 29 Juni, p. 213.
BONTHUIS (J. A.). — De **baanverzwaring** bij de Nederlandsche Spoorwegen. (5 000 woorden & fig.)

1950 **621** .33 (492)
Spoor- en Tramwegen, nr 12, 15 Juni, p. 187.
KOSTER (J. P.). — Eenige beschouwingen over het **onderhoud van de electrische installaties van het motorwagenmaterieel** der N. S. (4 500 woorden.)

1950 **625** .142 .2
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BROESE VAN GROENOU (H.). — Het **drogen van te creosoteren hout** volgens het Taylor-Colquitt proces (Vapour Drying). (4 000 woorden & fig.)

1950 **656** .215 (492)
Spoor- en Tramwegen, nr 15, 27 Juli, p. 237.
BOOGAART (J. H.). — Enige beschouwingen over de **electrische verlichting** bij de N. V. Nederlandsche Spoorwegen. (3 500 woorden & fig.)

1950 **656** .225 (73)
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Moderne Amerikaanse **goederenloodsen.** (2 000 woorden).

In Swedish (= 439.71).

Nordisk Järnbanetidskrift. (Stockholm.)

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OLSON (J.). — Turning of **hard metal wheels.** (2 500 words.)
PEDERSEN (P.). — Danish report. (800 words.)

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HERTZUM (A.). — **Ballasting and ballast transport.** Danish report *(Continuation* of No. 11-1949). (500 words & fig.)
TURUNEN (P.). — Finnish report. (1 700 words.)

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ROEMPKE (W.). — Reconstruction of the Southern **Underground Railway** in Stockholm. (1 300 words & fig.

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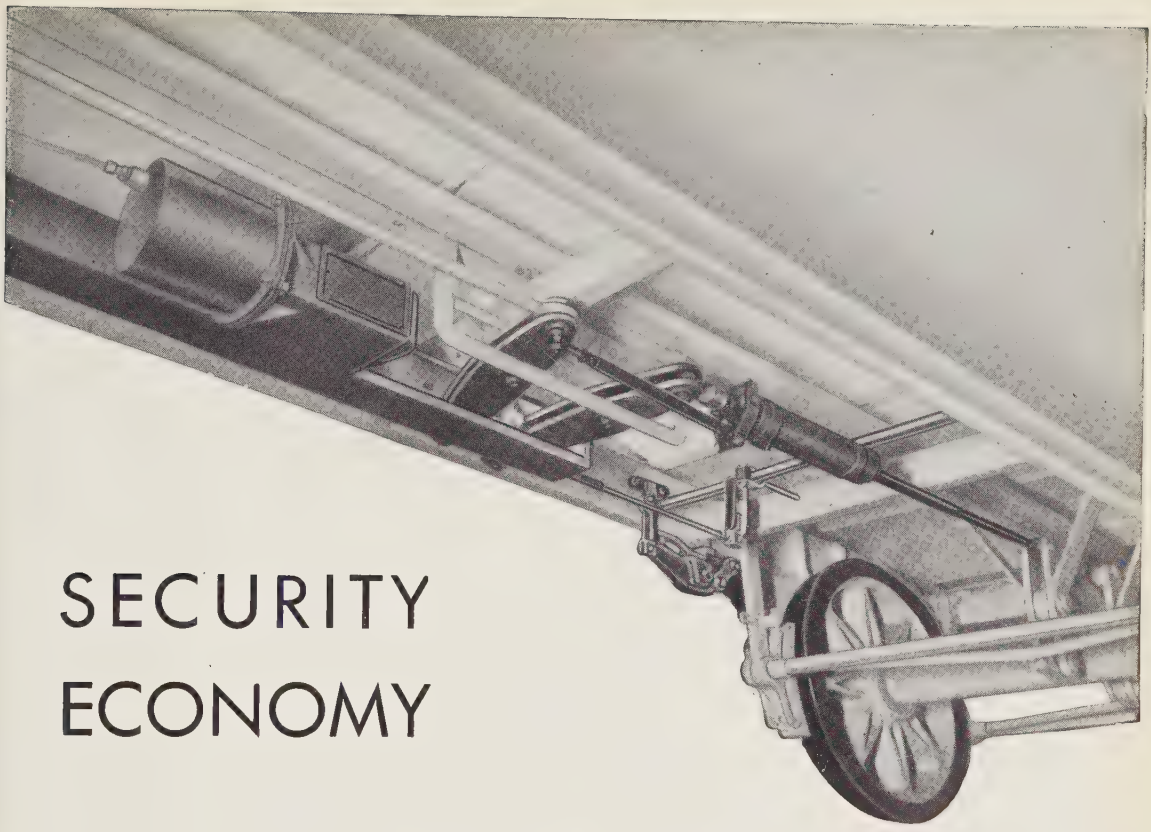

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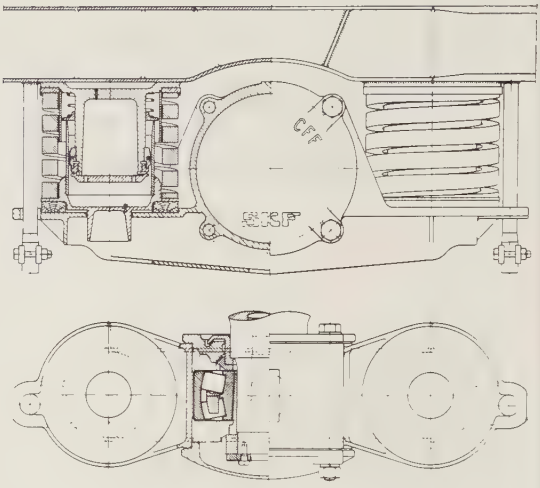

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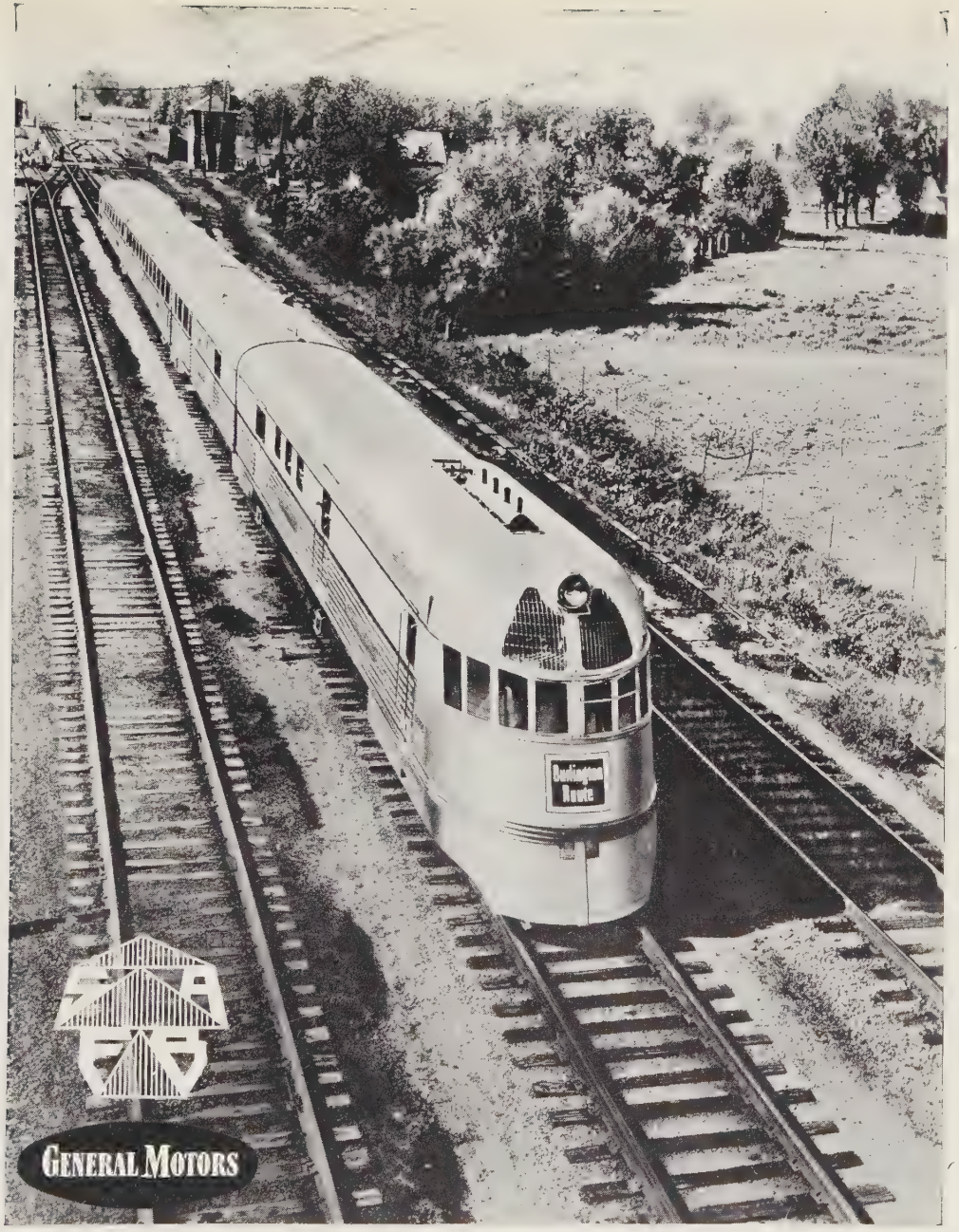

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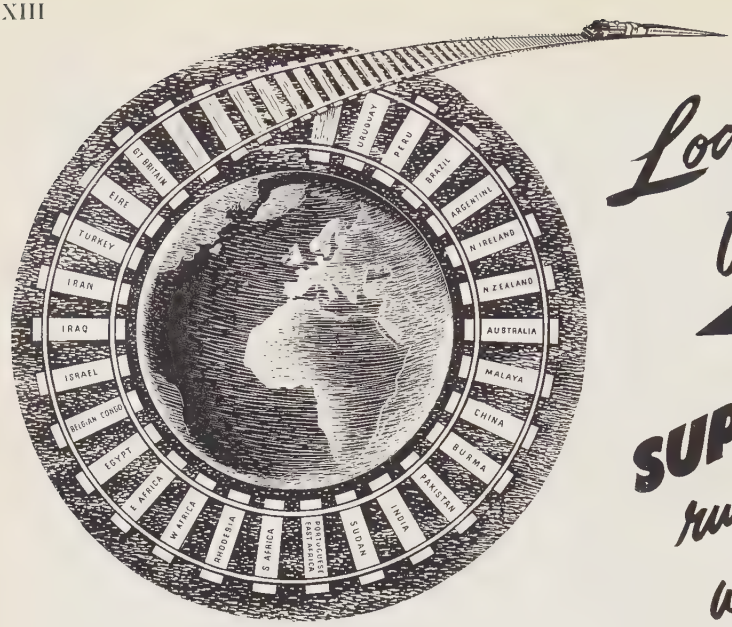

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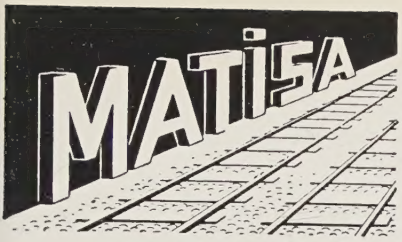

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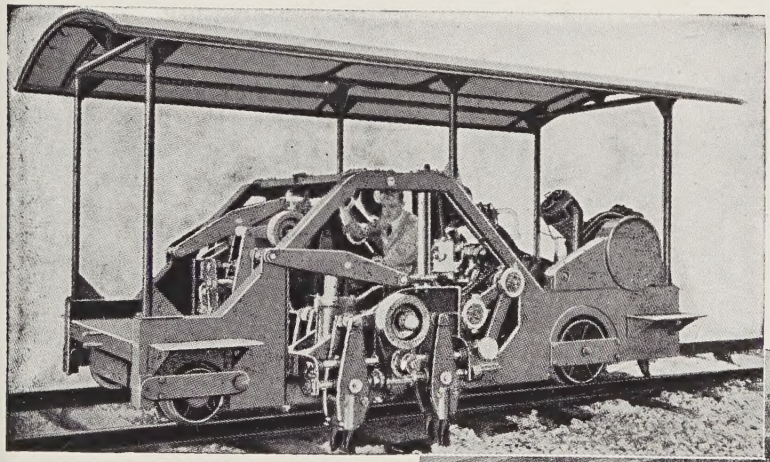

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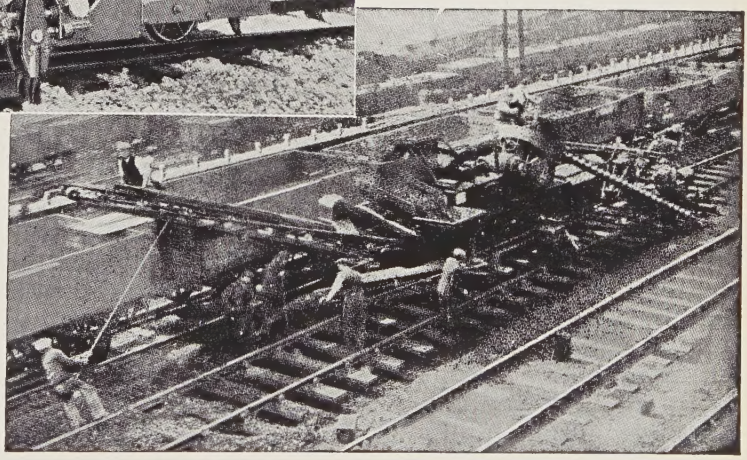

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